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The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

formerly

Practical Electrics

Over 175 Illustrations

HOW TO MAKE A

CRYSTAL SET

LOUD SPEAKER

See Page 83

12 Pages of EXPERIMENTAL RADIO

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The EXPERIMENTER

Vol. 4 **No. 2**

Contents For December

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THE EXPERIMENTER is published on the 15th of each month at 53 Park Place, New York City. There are 12 numbers per year. Subscription price is $2.50 a year in U. S. and possessions. Canada and foreign countries $3.00 a year. U. S. coin as well as U. S. stamps accepted (no foreign coin or stamps). Single copies 25 cents each. A sample will be sent gratis on request. Checks and money orders should be drawn to order of GERMOTT PUBLISHING CO., INC. If you change your address, notify us promptly, in order that copies are not miscarried or lost.

All communications and contributions to this journal should be addressed to: Editor, THE EXPERIMENTER, 53 Park Place, New York. Unaccepted contributions cannot be returned unless full postage has been included. All accepted contributions are paid for on publication. A special rate is paid for novel experiments; good photographs accompanying them are highly desirable. THE EXPERIMENTER, MONTHLY entered as second class matter October 14, 1921, at the New York Post Office under Act of Congress of March 3, 1879. Entered on September 15, 1924, at Post Office, Atlanta, Ga., Chicago, Ill., Los Angeles, Cal., San Francisco, Cal. Title registered at the Patent Office, Copyright, 1924, by GERMOTT PUBLISHING CO., INC., New York. The contents of this Magazine are copyrighted and must not be reproduced without giving full credit to the publication.

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Published by EXPERIMENTER PUBLISHING CO., INC. (Germott Publishing Co., Inc., owner) 53 Park Place, N. Y. City
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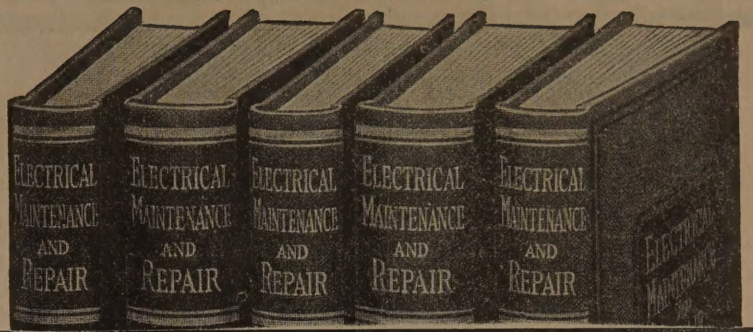

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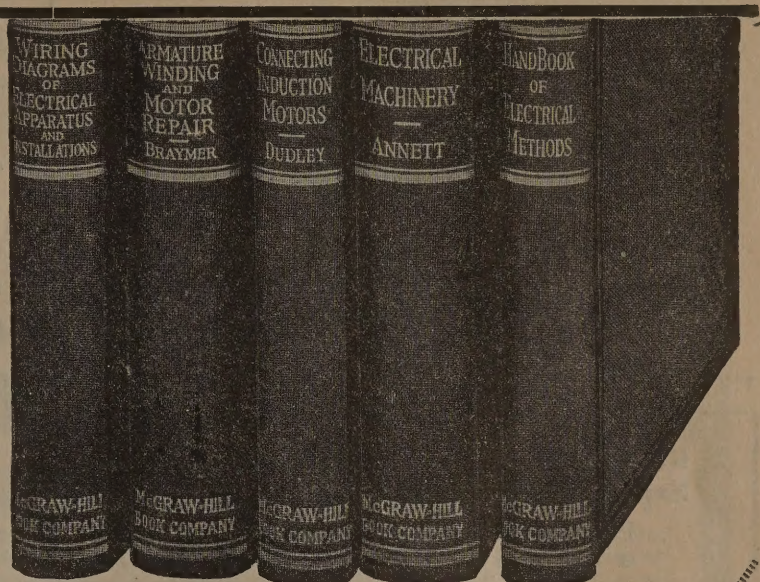

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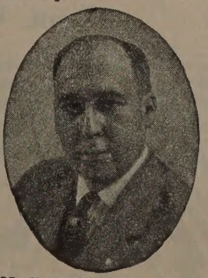

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Volume 4 No. 2

The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

December 1924

H. GERNSBACK, *Editor and Publisher* T. O' CONOR SLOANE, *Ph.D., Associate Editor*

How to Experiment

By Hugo Gernsback

"An ounce of experimenting is worth a pound of theorizing"

THERE is hardly anything more fascinating today than experimentation. Whether one is interested in electricity, radio or chemistry, each of these fields presents huge possibilities to the wide-awake individual. Whether you experiment for pleasure or otherwise, sooner or later you will be able to make your experimentation pay if you proceed along the right paths.

The writer started experimenting in electricity at the age of seven and has been at it ever since. Whatever success he may have achieved can probably be traced directly to his experimental work. At the age of thirteen he had a well-equipped electrical laboratory, and there was hardly a day that he was not engaged in some sort of experimentation. But the great lesson that the writer wishes to preach is the following:

Whatever experimenting you do, *plan it out beforehand* and know *why* you are experimenting. It is all right to make various kinds of experiments, but it is not all right if you do not know why you are doing it and what goal you wish to arrive at. And right here it is important to say that you will not be a successful experimenter unless you can keep at it continuously, and unless you can accustom yourself to systematic and assiduous work. Experimenting at best is always strenuous labor, whether done for pleasure or professionally. For that reason, one of the first rules to remember is that whatever you do should be done in a well-planned manner, never in a haphazard way.

Think out all of the steps beforehand and, most important of all, lay out your work on paper, mapping out all the successive stages. Then, before you touch anything, be sure that you have all the materials at hand. There is nothing more distracting, more annoying and more conducive to failure than to start working out a certain experiment without having all the material necessary to carry it out. As a rule, such experiments are doomed to failure. All of your materials must be ready, and not until then will experimenting seem a pleasure rather than hard work. If you can take yourself in hand and form this excellent habit you will have no trouble in your experiments and you will achieve success many more times than if you go ahead without planning beforehand.

The next most important thing to remember is notes. Such outstanding inventors as Edison, DeForest, and many others make it a rule never to perform any experiment, no matter how insignificant, without making notes. When the writer visited Mr. Edison recently, it became apparent why he achieved such success. He had in front of him continuously a small block of yellow note paper, measuring approximately $5\frac{1}{2} \times 4$ inches. As he proceeded he jotted down notes. He was careful to date the notes, and nearly all of them were initialed by him. In the evening, when the day's work is done, Mr. Edison looks over his notes and destroys those which he deems of no value. The important notes are then handed to Dr. Meadowcraft, his secretary, who takes charge of them in a systematic manner. These notes are not just filed away, but Mr. Edison has them bound in book form every month.

There are hundreds of such small bound volumes in Mr. Edison's library and each one is labeled on the backbone with the date. If Mr. Edison wishes to look up an experiment he made one year or twenty years ago he experiences no trouble in locating the particular note almost instantly. And these note books, by the way, have often won Mr. Edison a decision when it came to fighting an infringing patent. Often the mere date of making an experiment will prove priority over some other worker who may have made the same experiment, *but at a later date.*

Dr. Lee DeForest, of radio fame, and the inventor of the Audion, is also a great note jotter. By reading his biography, which is now running serially in RADIO NEWS, it will be seen that he started making notes of all his experiments while still a mere child. He remained faithful to this habit right along and has collected thousands and thousands of notes of all sorts of experiments. This is probably one of the reasons for his success.

The experimenter who takes no notes and does a lot of experimenting is unable to remember new and intricate experiments within a few months after they have been made; then when the subject comes up again, instead of referring to notes, he has to do the work all over again, losing valuable time. It is much better to look over old notes when one has the time and then leisurely pore over these notes and find whether improvements can be made on the particular experiment.

The writer advises the young experimenter to procure at any stationery store a small book, which can be had for 25 cents or less. The writer suggests that one note book be kept for every month, even if the entire book is not filled up during that period. The experimenter will in time, therefore, have a handy reference library in which he can look up details of any experiment which he has made, no matter how far back, which may prove very valuable. Such books are really worth their weight in gold, as the writer will explain in some future chats with the experimenting fraternity.

The Rotating Coin

By C. H. Ostermeier

A SIMPLE electrical trick which is easy to carry out and which will always attract attention at electrical shows, etc., is the Rotating Coin trick. Its operation depends upon principles which all electricians understand, namely the principles of the electric motor.

Purchase at an art or bric-a-brac store a fair sized statue of Buddha with an altar at the front of the base. Hollow out this altar about half an inch deep and one inch wide, as shown in the illustration. Mount two contacts at opposite sides of the hole, soldering leads to them and running them down through the base. Hollow out a place for a permanent magnet in the base so that the lines of force from the magnet will cut across the hole in the altar.

Fill the hole with clean mercury so that the contacts are just covered and place a new copper coin in the mercury. Now if a direct current is passed through the mercury the coin will rotate, the direction of rotation depending on the direction of the current with respect to the permanent magnet. Changing the direction of the current will change the rotation of the coin.

The ugly god looking down at the turning penny produces a very weird effect.

A rotating penny, floating in mercury on the altar of this Oriental god, lends a mysterious air to the idol. An invisible permanent magnet and an electric current sent through the mercury and the penny make of the arrangement a miniature electric motor, of which the penny is the armature.

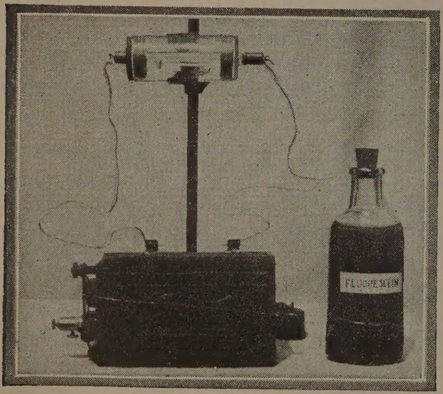
The Oriental god as shown here is Buddha, the great exponent of the value of quiet and meditation. A very eminent lawyer once told the writer that a thought was worth many hours of reading. There are many readers who measure their efficiency and the value of their lives by the books they read, but it really is in a sense impoverishing to the mind to rely too much on books.

Elsewhere we are describing the work of Faraday, and here we have the great Indian god meditating on an experiment really dictated by Faraday's work. The coin rotates mysteriously, and it was Faraday who evolved the theory by which its rotation was explained. It makes an attractive exhibition.

Fluorescent Fluid Geissler Tube

By Raymond B. Wailes

MANY experimenters possess the ordinary type of Geissler tubes which do not contain the fluorescent liquid sealed in an outer chamber surrounding the exhausted center tube in which the electrodes are sealed. The simple type of Geissler tube can be very readily con-



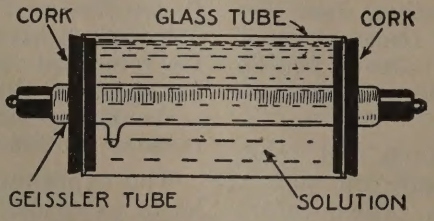
If the manufacturer has not provided fluorescent material within your Geissler tube, you can compensate for the deficiency by this ingenious method of surrounding the tube with fluorescein.

verted into one of the fluorescent-fluid types as the illustration shows.

A glass tube of about 1½ or 2 inches in diameter is procured. Its length should be a trifle less than the entire glass body of the Geissler tube now at hand. A length of tubing can be cut very easily from a longer piece by means of the electric glass cutter as described on page 554 of October, 1923 issue of PRACTICAL ELECTRICS.

This glass tube of large diameter forms the outer chamber in which the fluorescent liquid is placed and should be fitted to the Geissler tube by corks as shown, two being required.

Many liquids can be used in the outer



No extraordinary apparatus is required for converting the ordinary Geissler into the fluorescent type. A glass tube surrounding the Geissler tube contains the necessary fluorescent liquid.

chamber which has just been made. Quinine solutions are easily procured and are inexpensive. To make a fluorescent quinine solution, stir the contents of a five grain "quinine" capsule into about half a cup of water to which a few drops of acid such as sulphuric, have been added. The ordinary storage battery acid can be used. This renders the "quinine" soluble. The resulting solution is then used directly in the outer chamber.

A solution of fluorescein in water to which a little sodium hydroxide or caustic soda has been added produces a beautiful glow when the Geissler tube is operated by means of the usual spark coil.

Solutions of eosin, fresh stramonium leaves, some type of machine oils which have the characteristic blue "bloom" or bluish hue, all can be used with good results. A fluorescein solution is the best.

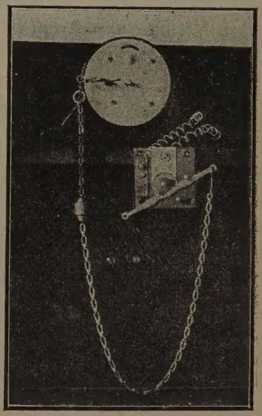
Quick-Action Alarm Switch

By Jacob Raible

THE switch shown here is for alarm clock operation. It is fastened to the wall with four little screws and the line wires connected to it. About six inches on either side of the switch a nail or pin is driven into the wall to hang the clock on, with its face toward the wall, or it may stand on a table.

The little hook on the end of the chain

No alterations or special mounting is required to adapt an alarm clock to the operation of an automatic switch. A weight attached to the end of a chain is released when the alarm key turns, and in falling opens or closes the switch.



may be put in either end of the switch lever, to open or close the circuit as desired. On the other end of the chain is a little link and fork hanger to engage the alarm wind key so that the motionless key will support the weight at the end of the chain.

The end may be forked so that it will engage any stiff-blade winding keys or there may be a link to take the lie-flush kinds. When the chain is in place at both ends it will hang in a U-shaped

(Continued on page 136)

Illuminated Watch

MANY times a person will wake up late at night and want to know what time it is. The radium-dial clock is good, but it must be placed close to the bed, otherwise is hard to read. A projector which will project the face of your own watch on the wall or ceiling of your bedroom is shown here.

First procure the lens equipment with its mounting from an old magic lantern, or lacking this mount any lens in a metal or heavy cardboard tube so that the focus may be adjusted, will answer the purpose. Then construct a wooden box large enough to hold four flashlight batteries and two six-volt lamps, as shown. One side of the box should have an opening at the bottom through which to insert the watch in the center of the field of the lens. Small brads or cleats may be used on the bottom of the box to locate the watch at the proper point.

That laziness rather than necessity is the mother of invention is demonstrated by this ingenious device by means of which you can see the time indicated by your watch at any time in the night, without inconvenience. A pear switch lights two lamps in the case, whereupon an image of the illuminated dial of the watch is cast on the ceiling.

The batteries are connected in series by soldering them together with small wire, and the lamps may also be connected thus. If stiff wire is used no sockets are necessary to support the small lamps. A length of lamp cord and a pear switch are then connected in circuit as in the diagram.

Finish the cabinet similarly to the bedroom furniture and set it on the dresser or table, running the cord over to the bed. The image of the watch, greatly enlarged, will appear on the ceiling when the lens is focused right, and the lamps are turned on by the pear switch. The image will be reversed so the sleeper, seeing the reversed image, must be ready to correct it mentally.

$100.00 Prize Contest

THIS time we have a brand new idea in a contest that should be of much interest to all of our readers. Since we changed the name of the magazine to THE EXPERIMENTER you will note that in our two cover illustrations we have used only "*How to make it*" or *Experimental* subjects.

The subject on the November cover was "How To Make an Electric Water Finder." The subject on the present cover is "How to Make a Crystal Set Loud Speaker." Since we changed the name we have established the policy that *every* cover will be a "How to Make It" or experimental idea, this being more in line with what our readers demand.

Now we admit that it is not an easy thing to get up a good cover every month with a good popular subject. The Editors have to worry not a little and strain every nerve in order to present a new subject every month. So we decided to put it up to our readers and let them earn money by supplying us with some of the ideas, hence this prize contest.

This is what we want:

(1°) First of all a rough illustration of the idea, but understand that THIS IDEA MUST EMBODY SOME NEW OR UNUSUAL EXPERIMENT, electrical, chemical or radio.

(2°) Commonplace ideas will have little chance of winning a prize. It is the UNUSUAL thing that attracts readers to buy the magazine and this is what we want to feature on the cover.

(3°) If possible you should have tried the experiment and built the apparatus or instrument yourself. Mere suggestions are not greatly favored in this contest, although if for any reason you should not be able to build the device yourself, good drawings might then be accepted by the Editors if the idea is good.

PRIZES
$100 in Gold

1st Prize	$50.00	in gold
2nd "	20.00	" "
3rd "	15.00	" "
4th "	10.00	" "
5th "	5.00	" "

(4°) Your entry into the contest must be accompanied by a "How to make it" article of not more than 2,000 words, describing the idea in full detail.

(5°) The article describing the idea must be either written in pen or typewritten. No penciled matter can be considered.

(6°) Drawings should be made in pen and ink and if photographs of the design are submitted, such photographs must not be smaller than 5 inches by 7 inches.

(7°) All manuscripts and photographs must be sent in flat. Rolled manuscripts or photographs are not acceptable. Entries to this contest cannot be returned by this magazine. Ideas not winning a prize may be published in the magazine at our option at regular space rates.

(8°) Should two contestants submit the same idea, then the same prize will be paid to both.

(9°) Models need not be sent with the entry unless the contestant desires to do so.

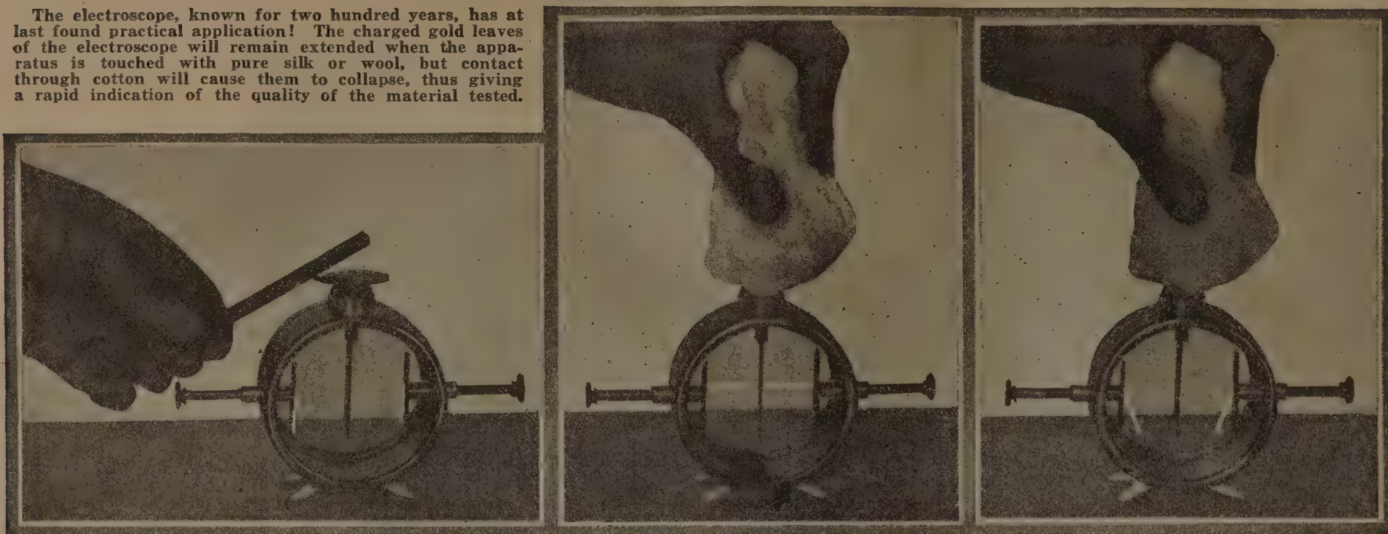
(10°) This contest is open to all except employees of this company and their families.

(11°) This contest closes on February 1st, 1925, 12 noon. No contributions postmarked at a later date can be considered.

NEW THINGS ELECTRIC

Electric Wool-Silk Tester

The electroscope, known for two hundred years, has at last found practical application! The charged gold leaves of the electroscope will remain extended when the apparatus is touched with pure silk or wool, but contact through cotton will cause them to collapse, thus giving a rapid indication of the quality of the material tested.



FOR the benefit of our readers we give the above name of an apparatus for testing the purity of wool and of silk. Pure dry wool and silk are non-conductors of electricity even at the high potential of a static charge.

The apparatus which we illustrate is a gold leaf electroscope. The side plates operated by the horizontal rods slide in and out. Attached to each is a piece of gold leaf. There is a central plate parallel to the plates, carrying the gold leaf, and this is insulated from the case of the instrument. A rod of vulcanite is supplied. The rods carrying the gold leaf are drawn out as far as they will go.

The first process in using the instrument is to charge it. This is done by rubbing the rod of vulcanite against the sleeve of the coat or other animal fabric and rubbing it for its length down the edge of the button. After one or perhaps two or three repetitions of the process, the gold leaves, which hitherto have been practically invisible as they lie against the plates, spring out and stand rigidly horizontal nearly touching the central plate.

It is the excitation of the plate that holds them in this position. If now the plate is grounded by touching the button with the finger, for instance, the pieces of gold leaf instantly fall, seeming almost to disappear. In use, the central plate is charged as described.

The fabric to be tested is touched to the button. If it is pure silk or pure wool and of course it must be dry, no effect will be produced upon the gold leaf. It will stand out horizontally, quite immobile; but if there is the least bit of impurity, cotton mixture or "loading", the leaves will fall instantly.

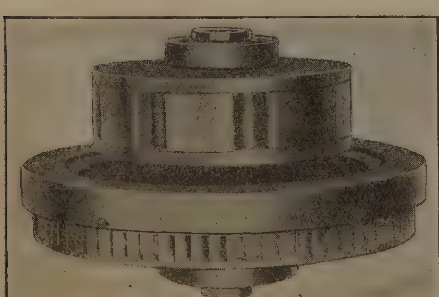
It is quite interesting to test different silks. Some produce absolutely no effect upon the gold leaf; others give it a slight tendency to descend, it may only go down a fraction of an inch, while others instantly affect it and it drops. Others cause the leaf to drop but it immediately springs back. The degree of activity gives an idea of the purity of the fabric. The manufacturers say that science has discovered that any material which offers a resistance to the passage of electricity, often offers similar resistance to the passage of heat, and silks and woolens are commonly used to preserve the heat of our own bodies.

This apparatus comes from Italy and bears the imposing name of The Lanasetoscopio, which literally translated, means I See Wool Silk. It is certainly a most interesting apparatus, a scientific plaything, in addition to its practical value.

Be sure to discharge it and drop the gold leaf before pushing in the rods.

Pneumatic Miner's Lamp

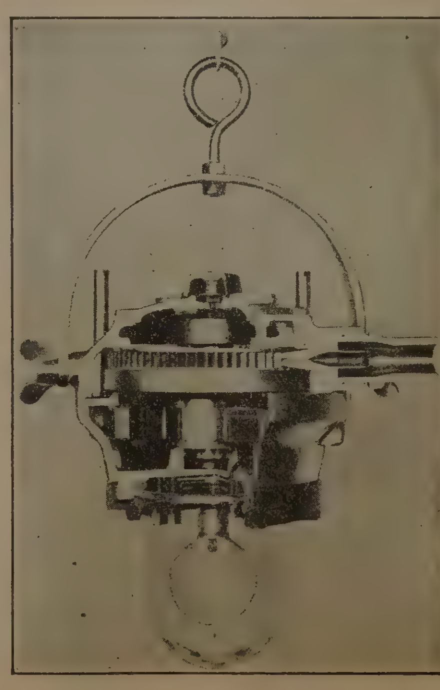
THERE is a certain amount of danger involved in carrying a long electric wire through a mine where gas may be evolved, and especially where switches are turned on and off and connections made and broken. These operations are apt to give rise to sparks which if fire-damp is present may be the cause of an explosion.



The small turbo-generator used to supply power for miners' lamps has a pneumatic-turbine rotor and a rotary permanent magnet for the generator field, mounted on the same shaft.

The illustrations give two views of a miner's lamp which is self-contained and which operates by the compressed air used in the pneumatic mining machinery such as drills and under-cutters.

The case, which is quite compact, contains a turbine to be operated by the compressed air. Attached to the shaft of the turbine is the rotor of an electric generator. The generator is an alternator whose field revolves, so that there are no rubbing contacts, and the operation is entirely inductive. This absolutely precludes sparking.



One of the greatest causes of mine catastrophes is removed by this miner's lamp connected to a small pneumatic turbo-generator, all mounted in a compact case in which a pressure considerably above atmospheric keeps explosive gases from coming in contact with the incandescent lamp.

The lamp and apparatus are sealed in by the glass cover, which also protects the electric lamp, and the casing is in communication with the exhaust side of the turbine, so that a constant pressure of about two pounds per square inch is

(Continued on page 136)

EXPERIMENTAL RADIO

Conducted by Clyde J. Fitch

A Crystal Set Loud Speaker

THE microphone as a relay of telephonic currents undoubtedly offers more field for research to the radio experimenter than any other phase of the science. Before the debut of the vacuum tube when practically all wireless communication was carried on with crystal receivers many attempts were made to produce a suitable microphonic relay for intensifying the received currents, and thereby increase the range of the apparatus. Some very good progress was made in this line, but unfortunately for the microphone, the vacuum tube made its appearance and experimenters turned their attention to the tube with the result that little work has been done since on the microphone.

The coming of the vacuum tube did more than crowd out the microphonic amplifier; it made radio so popular that it is now used as a public utility and enjoyed by thousands, and it brought back the crystal receiver to the many who do not desire the more expensive tube sets. And these crystal users are busy at work in perfecting the microphone for amplifying purposes. In the very near future we may expect a crystal receiver that successfully operates a loud speaker by making use of the sensitive microphone. In fact some of the microphone relays shown in the illustrations will do this now but they have a few draw-backs that make them undesirable for universal use. It only remains for the fraternity of experimenters to perfect the device.

In our illustrations we show several forms of microphone amplifiers. These are given as a basis for experimenters to work on.

Perhaps the simplest form of relay is that shown at Fig. 1, comprising a microphone button attached to the diaphragm of a telephone receiver. The complete crystal receiver circuit is shown in this illustration. Although the scheme works with a fair degree of success it is very critical in adjustment and the adjustment is not permanent. With its use a low resistance loud speaker is required, one of about five to ten ohms resistance. Those who have the old style Magnavox, having a field electromagnet excited by a battery, can easily adapt it to this circuit by disconnecting the input transformer. The floating coil attached to the diaphragm of this loud speaker has about the correct resistance for this work. Otherwise it will be necessary to procure a low resistance loud speaker of some other make or to rewind a standard radio loud speaker for this purpose.

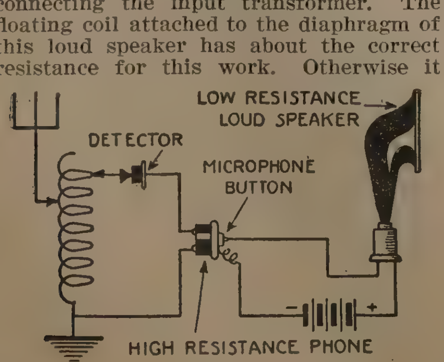
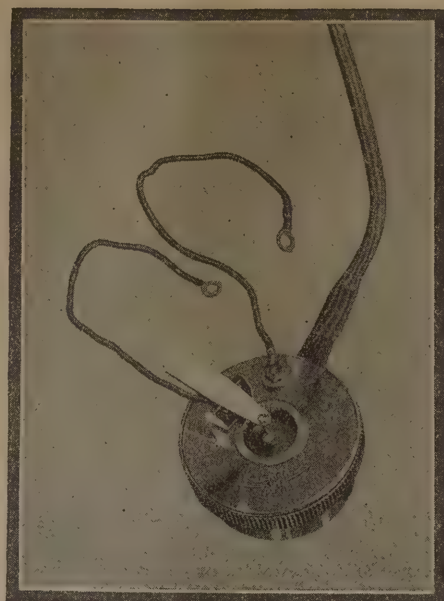


FIG. I

An elementary form of microphone relay that gives good results on strong signals. This type makes use of the well-known transmitter button mounted on the diaphragm of a telephone receiver. A low resistance loud speaker is used.



Photographic view of a microphone relay constructed in the EXPERIMENTER LABORATORY. The microphone contact takes place between a pointed carbon pencil and a carbon diaphragm. A steel disc is cemented to the underside of the carbon diaphragm so as to be actuated by the telephone magnets.

The following instruments will be required for conducting these experiments:

- 1 crystal receiving set.
- 1 Baldwin phone.
- 1 Rico 1,000 ohm phone with metal cap.
- 6 Rasco carbon diaphragms, with carbon grains and carbon balls.
- 1 transmitter button, Skinderviken or Newman-Stern.
- 1 low resistance loud speaker.
- 1 telephone induction coil or modulation transformer.

It is a simple matter to rewind a loud speaker magnet for five ohms. First take the instrument apart and remove the fine wire on the bobbins. Then rewind the bobbins with No. 26 enameled copper wire. The resistance of the finished magnet is not critical. Simply wind as many turns as possible on the pole pieces and connect them as they were before.

Those who do not desire to rewind their loud speaker may obtain good results by using a step-up transformer between the microphone and high resistance loud speaker. Although the arrangement is not nearly as good as when using a low resistance loud speaker without the transformer, it will be suitable for conducting experiments with the microphone and will in no way affect the results. For this purpose a transformer having a low resistance primary and a high resistance secondary is required. A modulation transformer such as is used for radio telephone transmission work or a telephone induction coil will be suitable. A suitable transformer may be constructed as shown in Fig. 2. It consists of an iron wire core four inches long by three-eighths inches in diameter. The primary winding consists of four layers of No. 26 D. C. C. wire wound directly on the core. Paper insulation is placed over the primary and the entire space between the two end blocks is filled with No. 32 enameled wire.

Going back to our microphone experiments, it was found that the scheme shown at Fig. 1 did not work very well unless the input currents were very strong. In fact a weak station will hardly be audible. The reason is that the button is comparatively heavy and does not follow audio vibrations of small amplitude. In order to amplify weak currents, a very light contact is required, and the contact between a portion of a tungsten lamp filament and a polished carbon plate is excellent. This is clearly shown at Fig. 3. The tungsten filament is attached directly to the diaphragm, and it is not heavy enough to interfere with the vibrations. To attach the wire, it is best to solder one end of the diaphragm. A piece of a polished carbon diaphragm is used for the other electrode. The pressure between this and the wire is made adjustable by the adjustment screw, as shown.

This method gives very good results. The volume and quality of the reproduced music depends largely upon the pressure and the current flowing through the contact. One dry cell is sufficient for the operation, whereas in Fig. 1 three dry cells are required.

A very simple microphone amplifier constructed in the EXPERIMENTER LABORATORIES is shown in Fig. 4. This amplifier is also shown on our cover illustration. When used with a good crystal receiver local broadcasting stations were received with good volume on a loud speaker.

This amplifier is so easily constructed that it would be advisable for experimenters to make two or three and operate them in cascade. A "Rico" loud speaker phone unit is used because this phone has a metal cap. The iron diaphragm is removed and a carbon diaphragm substituted. Before clamping the carbon diaphragm in place a disc of iron five-eighths of an inch in diameter cut from the iron diaphragm is cemented to the center of the carbon diaphragm. To do this roughen the surface of the iron disc by criss-crossing the disk with a sharp knife point;

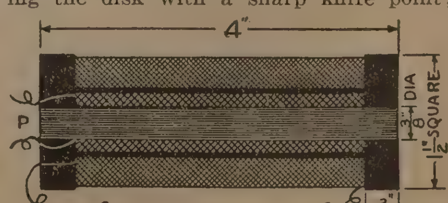


FIG 2

Details of a microphone transformer. By means of this instrument a high resistance radio loud speaker may be used for conducting these experiments.

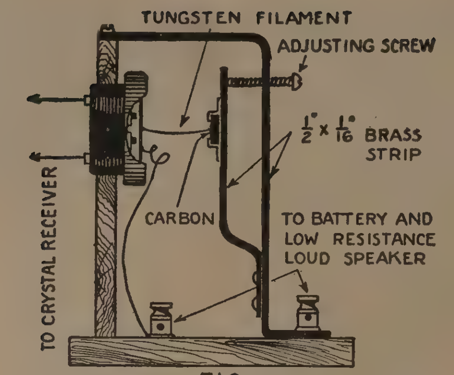


FIG. 3

The construction of a super-sensitive microphone relay comprising a portion of a tungsten lamp filament in contact with a carbon button. A very light contact is obtained, and the weight of the tungsten wire does not interfere with the vibrations of the diaphragm.

then sprinkle a few grains of sealing wax upon it; hold it over a hot soldering iron until the wax melts and then clamp it firmly to the carbon diaphragm. When cool it will adhere securely. Paper washers, equal in thickness to the disc, are placed between the shell rim and the diaphragm, so as to give the proper air gap between the pole tips and the iron disc.

A brass capped carbon pencil taken from an old small flashlight battery is soldered to a lever as shown and mounted so as to press lightly on the carbon diaphragm. A sharply pointed pencil gave the best results. The lever is made of brass and supported by two pointed bearings formed by soldering pin points to the lever. It is well to solder a fine copper wire to the lever and its support so as to short circuit the high contact resistance of the pointed bearings. The support is insulated from the shell as shown.

It was found that the lighter the contact the greater the amplification, and in order to vary the contact pressure the complete unit should be tilted. Our cover illustration shows the unit mounted on a framework for tilting purposes. Another way is to mount the entire unit in a box packed with absorbent cotton so that it will not pick up outside noises and to tilt the entire box for obtaining adjustment. A battery of two dry cells gave excellent results with this unit. A low resistance loud speaker was used.

Those who experiment with microphone amplifiers will no doubt strike other ideas that will improve the device. For example, the galena crystal may be mounted directly on the vibrating phone magnet, so that the catwhisker contact acts as both detector and microphone amplifier. We know of no one who has tried this method.

In conducting experiments with micro-

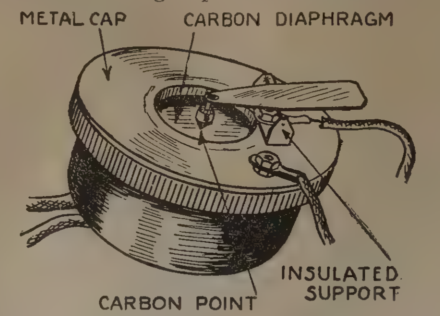


Fig. 4. Assembling drawing of the microphone relay shown in the photograph. The finished instrument should be mounted in a sound-proof box to prevent feed-back howling from the loud speaker.

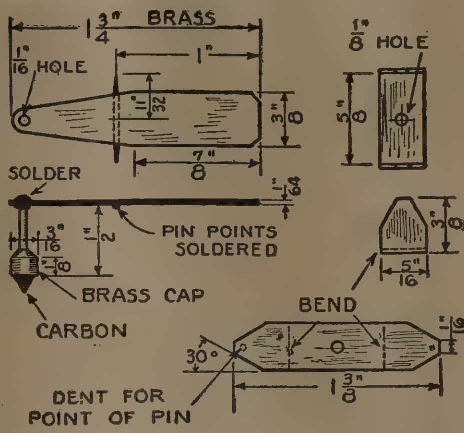


Fig. 5. Details of the parts required for building the microphone relay shown in the other illustrations and also on our front cover.

phone amplifiers, one should be careful as to the location of the instruments. If the loud speaker is placed near the microphone, the microphone will pick up sound from the speaker and a loud howl will be the result. Noises, and footsteps in the room, will also be picked up by the microphone and be reproduced in the loud speaker, which should be placed as far as possible from the microphone to avoid this trouble, and after a suitable microphone has been constructed it should be enclosed in a sound proof box.

The microphone amplifier, when carefully constructed, can replace one or two vacuum tubes. It is the indispensable adjunct of all crystal receiving sets, and its development will bring many new enthusiasts into the radio field.

(To be continued in our next issue)

Single-Tube Reflex Experiments with the Hook-Up Board

(Continued)

By Clyde J. Fitch

IN our last month's issue we showed a number of single tube reflex circuits, many of which were standard and practically all of which have been described elsewhere. The experimenter would do well to try each of these circuits before attempting to hook up the following ones. The circuits next to be described require many new instruments in addition to the ones shown in the photographic views published in the November issue. Many of these circuits have never before appeared in print, and they offer a wide field for experimenting. We are reproducing herewith a photograph of the hook-up board with many new instruments mounted on it. One of the illustrations shows how the hook-up board looks with circuit No. 13 connected. We are giving on column 2 a number of instruments required for making the following experiments:

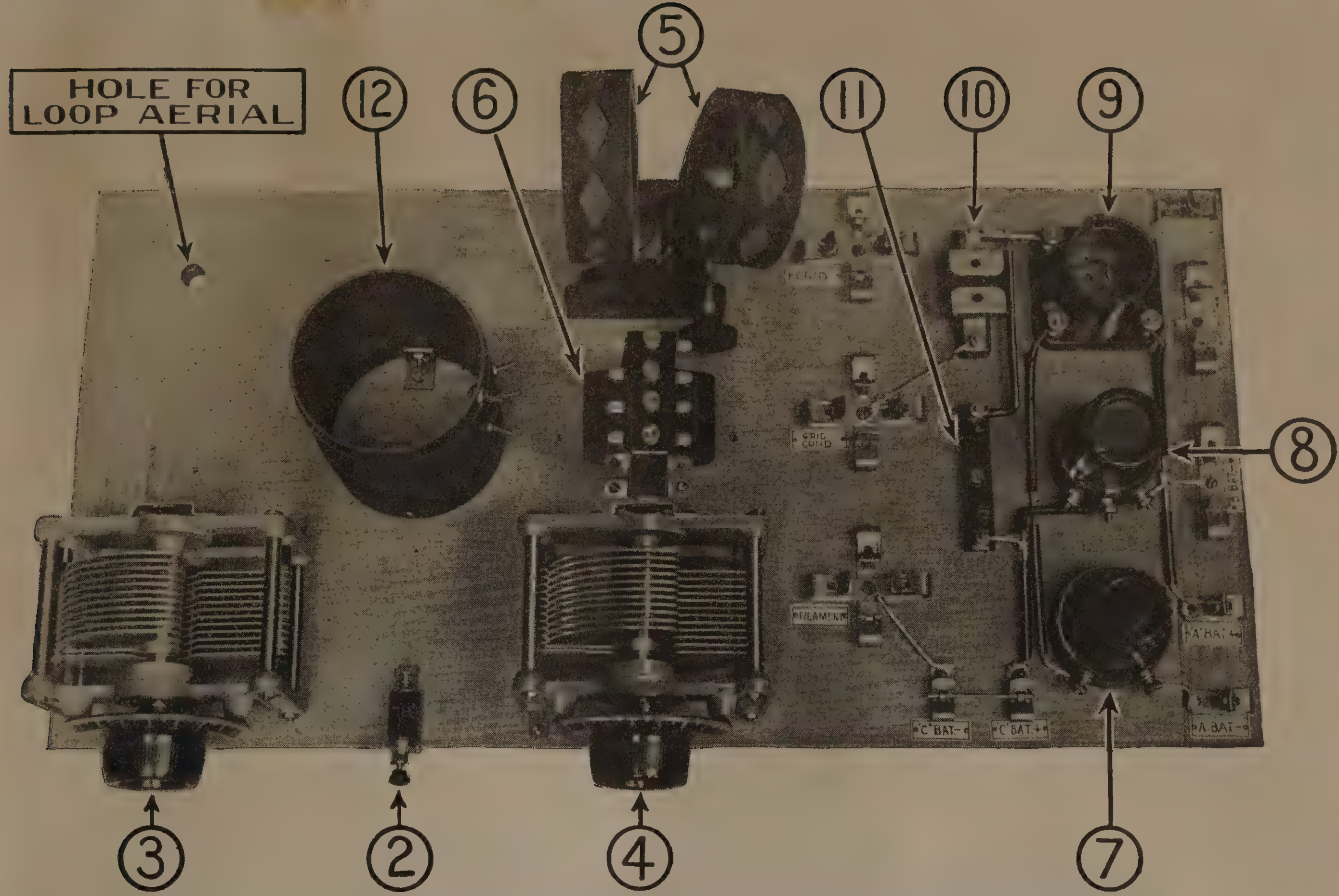
- 1 hook-up board made according to the details in the November issue.
- 2 *Erla* fixed-adjustable crystal detector.
- 1 *National Air Phone* calibrated transformer.
- 2 600 turn honeycomb coils with mounting and several smaller size honeycomb coils.
- 1 *Ritter* Collapsible loop aerial.
- 1 *Bradleyohm* Variable grid leak.
- 1 *Rasco* radio frequency transformer.
- 1 *Rico* Oscillator coil constructed according to Fig. 15.

It has been found that the *Rasco* radio frequency transformer is one of the best for use in reflex circuits. Those who desire to build this transformer will find the necessary constructional details in Fig. 14. The wire is wound in five grooves cut in the wooden form. The primary consisting of 81 turns of No. 40 S.S.C. wire is wound in the second and the fourth groove as shown, 40½ turns in each groove. The secondary consists of 169 turns of the same size wire wound in the other three slots, with 56 turns in the first and last groove and 57 in the third groove. When using this transformer it is well to try reversing both primary and secondary connections as the instrument works well only when properly connected.

The oscillator coil has two windings on a three-inch bakelite tube. One winding has 20 turns of No. 24 insulated wire and the other winding has 50 turns of the same size wire wound in the same direction.

Those who build reflex sets, especially single-tube ones, no doubt wonder why these sets do not give as good results as they are supposed to. For example, a single tube straight reflex circuit should apparently give the same amplification as a circuit employing a one-tube radio frequency amplifier, crystal detector, and a one-stage audio frequency amplifier. Hardly one set out of ten will do this, yet the connections will be correct in each set. The indication is that the fault must be in the design of the apparatus. The transformer may not have the correct ratio, condensers may be too large in capacity, or any number of things may cause the trouble. This is one reason why the hook-up board was made, to enable experimenters to try out various instruments in the same circuit in order to select the best combination. A few lines pointing out just why one set of instruments will work and another set will not work may not be amiss. For our explanation we will refer to any standard reflex circuit, such as the one shown in Fig. 1.

In this circuit the radio frequency currents are impressed upon the grid and filament of the tube, repeated in the tuned plate circuit, and detected by the crystal detector; the rectified or audio frequency currents pass through the step-up transformer and are impressed upon the grid and filament of the same tube. They are amplified by the tube and repeated in the telephone headset. Thus the tube amplifies both radio and audio frequency currents simultaneously. To explain why we do not obtain the amplification that we are entitled to, we must consider the rectifying action of the tube as well as that of the crystal. On account of the rectifying action between the grid and filament of the tube, the incoming radio frequency currents build up a negative charge on the grid side of the fixed condenser (C) across the secondary of the audio transformer. This causes a reduction in plate current and the signal is heard in the headset with the crystal disconnected. With the crystal connected, the rectifying action of the crystal builds up a negative charge on one side of the condenser (C_1) connected across the primary of the audio transformer. Thus for each group of incoming oscillations a negative charge is impressed across both the primary and the secondary windings of the audio transformer, setting up a



The hook-up board is clearly shown with new instruments mounted on it. The numbers designate the following instruments: 2, crystal detector; 3 and 4, variable condensers; 5, honeycomb coils; 6, amplifying transformer; 7, rheostat; 8, potentiometer; 9, socket; 10, grid condenser; 11, grid leak; 12, oscillator coil. These numbers correspond with those in the other illustrations.

current flow in both windings, which, from the nature of the circuit, must oppose each other, and unless the ratio of the transformer suits the constants of the other instruments, the transformer is useless. It is on this account that experimenters have obtained as good results with the crystal and transformer removed as with them connected. Now that we know the trouble we will see how it can be avoided. It may be well to mention first that this circuit, Fig. 1, is one of the simplest and best reflex circuits in existence today. It has the disadvantage of picking up audio frequency noises from lighting circuits, the amount of disturbance, of course, depending upon the location of the set.

Improved Reflex

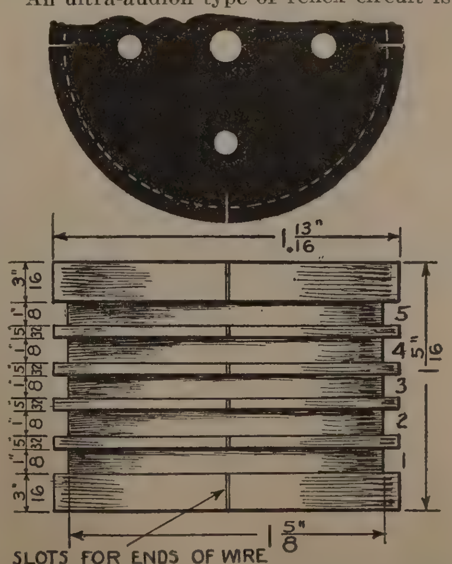
Fig. 2 shows a circuit in which the rectifying action of the tube has no effect on the action of the audio transformer. This is accomplished by connecting two fixed condensers in the grid lead (C_1) and (C). Condenser (C) is of comparatively large capacity, .002 mfds., for it must pass both radio and audio frequency currents. Condenser (C_1) is of small capacity, .00025 mfds., as it should by-pass the radio frequency currents only. The grid leak (R) is required. It should be of one-half to one megohm. With this circuit, the negative charges that accumulate on the grid must leak off through the grid leak (R); they cannot leak off through the secondary of the transformer on account of the blocking condenser (C), and therefore cannot balance out the current in the primary of the transformer. Experimenters should obtain very good results from this circuit. The remainder of the circuit needs no special comment as it is standard; all of the circuits shown in this issue and also last month's issue should be tried out with the double grid condenser.

Simplified Reflex

A simplified reflex circuit with the added improvement of the extra grid condenser is shown in Fig. 3. All this circuit requires is a standard three circuit tuner, such as the type shown in the photographic views in last month's EXPERIMENTER. A crystal detector and audio transformer are connected across the tickler winding of the coil. The secondary is connected across the small grid condenser as shown. Note that the condensers have been reversed from the locations shown in Fig. 2, merely to show that there are two ways of obtaining the same result.

Ultra-Audion Crystal Hook-Up

An ultra-audion type of reflex circuit is shown at Fig. 4. No audio transformer is used in this circuit. It is interesting to note that there is no direct connection from aerial to ground, the capacity between the primary and secondary coils of the tuner being sufficient to by-pass the current. This circuit oscillates continuously, unless the filament rheostat is turned down far enough. Many interesting experiments can be performed with this circuit as it is somewhat of a freak and acts very peculiarly. Occasionally extreme distances are covered in its use.



Wooden form for constructing the Rasco radio frequency transformer. The experimenter may turn this form out on a lathe and wind the coils according to the directions given in the text.

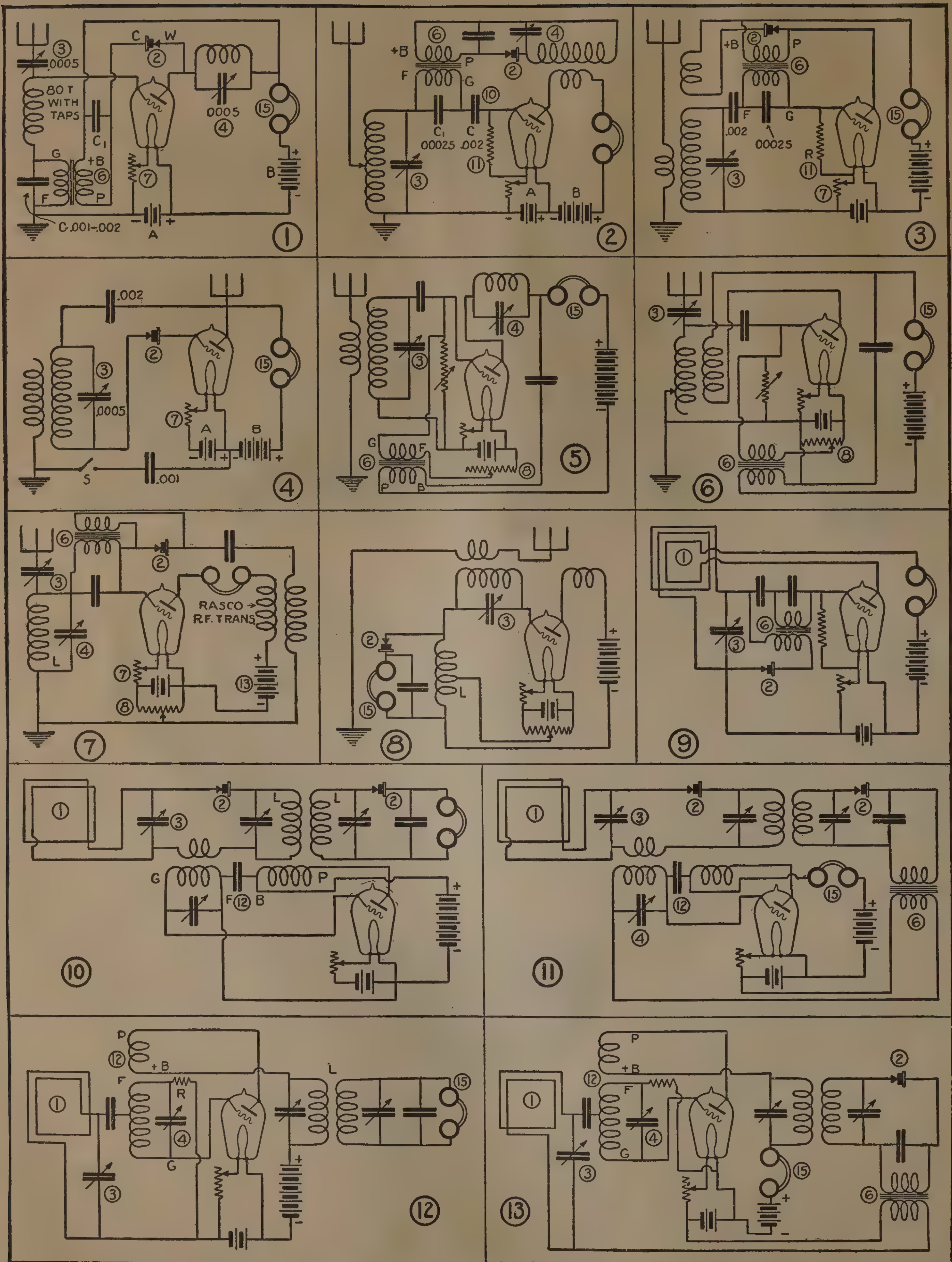
Peck's Reflex

Peck's reflex circuits use no crystal detectors at all. The tube is used as a radio amplifier, detector, and audio amplifier. The action resembles audio frequency regeneration, with an audio frequency transformer for the feed-back coupler. Figs. 5 and 6 show two of these circuits. Both are easily tried on the hook-up board, the only additional equipment required being a variable grid leak.

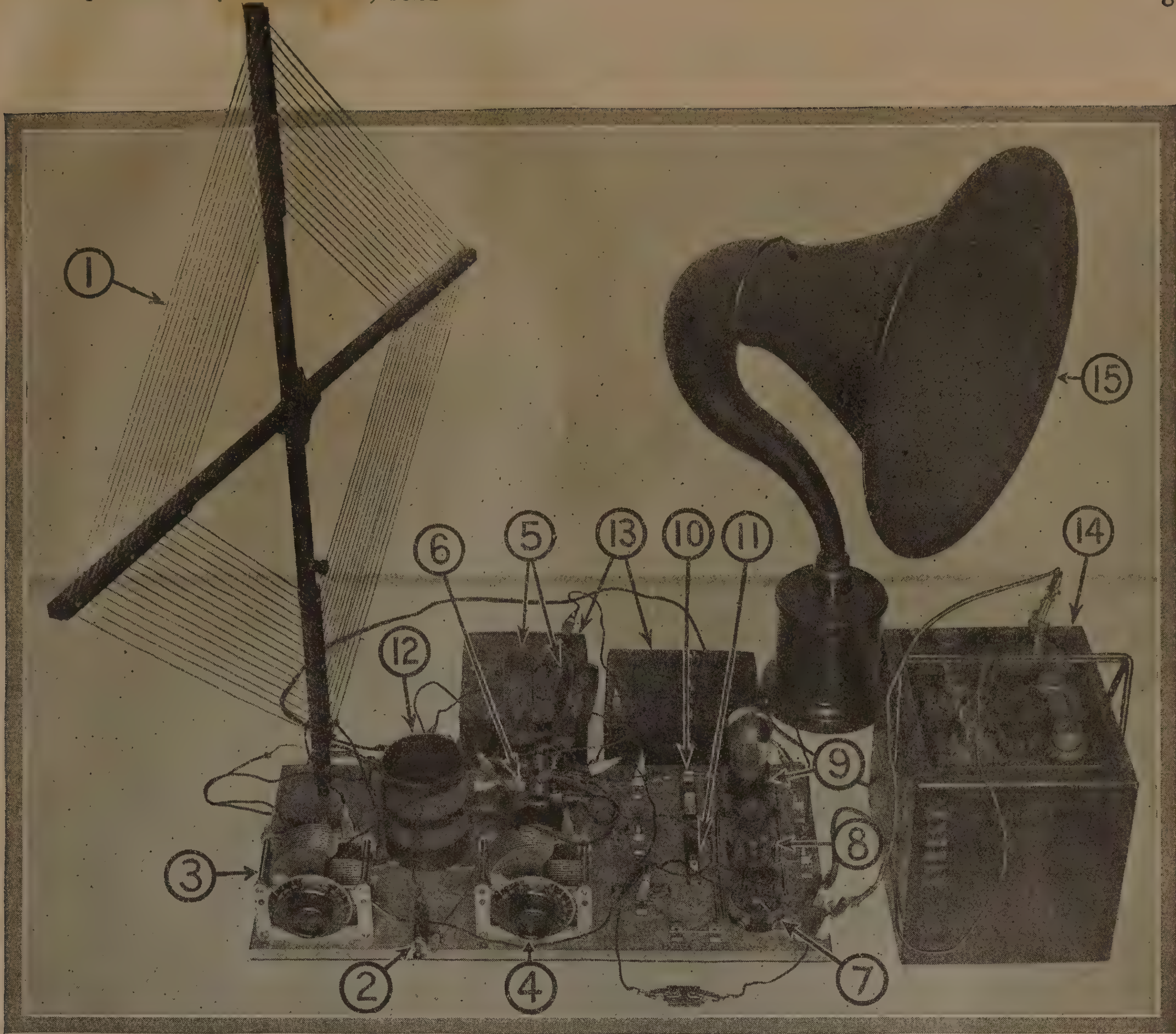
Of course, with an audio frequency feed-back connection, the circuit will howl at audio frequency unless the feed-back is controlled. This is accomplished by adjusting the grid leak. If the circuit doesn't work at first try reversing the transformer connections. A variable grid leak should also be tried across the primary of the transformer. The hook-up shown at Fig. 5 has a tuned plate circuit for regeneration; in Fig. 6 a tickler feed-back is employed. Honeycomb coils of about 60 and 100 turns each may be used in this circuit.

Simple Reflex

A simple reflex circuit that gives exceptional volume on local stations is shown in Fig. 7. This hook-up is easily connected on the hook-up board and requires few clip and tip leads. A Rasco R. F. transformer is used and the oscillations are controlled by the potentiometer.



Thirteen single tube hook-ups that may be tried on the hook-up board. Small numbers indicate the instruments shown in the photographic views which are numbered correspondingly. Circuit No. 1 is a simple reflex circuit that gives very good results. Circuit No. 2 is a standard reflex circuit with the added improvement of a blocking grid condenser, the action of which is described in the text. Circuit No. 3 is a simplified reflex embodying the improvement of circuit No. 2. Circuit No. 4 is a peculiar tube-crystal hook-up. Circuits 5 and 6 are two forms of Peck's no-crystal reflex hook-ups. Circuit 7 employs a fixed R. F. transformer. 8 shows the oscilloflex circuit. 9 is a single tube reflex that works with a loop. Circuits 10 and 11 are superheterodynes and circuits 12 and 13 are tropadynes.



The hook-up board with circuit No. 13, connected. Note the number of connections required for this complicated hook-up. It is one of the best single-tube hook-ups there is, as it operates a loud speaker from a single tube when using a loop aerial. In addition to the instruments shown in our hook-up board illustration the following are used: 1, loop aerial; 13, "B" battery; 14, "A" battery, and 15, loud speaker.

The experimenter may try various sizes of fixed condensers across the secondary of the audio transformer and he may also try two grid condensers as shown in Fig. 2. When the proper combination has been found a very good one dial single tube receiving set can be made.

Oscilloflex Circuit

In the oscilloflex circuit oscillations are generated by the tube continuously, but the oscillations are of an extremely high frequency, having a wave length of about 100 meters. Fig. 8 shows the circuit. The high frequency oscillations from coil (L) cause a current to continuously flow through the crystal and head phones. The amount of current depends upon the grid potential, which is adjusted by the potentiometer and varied by the incoming signal. In other words the signal current modulates the high frequency oscillation. A standard three circuit tuner is used in this circuit. The coil (L) may consist of 50 turns of No. 18 D. C. C. wire on a three-inch tube with a center tap.

Loop Reflex

Many improvements are embodied in the loop receiver shown in Fig. 9. The tickler or feed back coil is mounted within the loop, and may consist of two turns mounted so that the coupling is variable. Thus we have regenerative amplification. Rectification is obtained by the crystal. The rectified current is passed through the audio transformer and impressed on the grid and filament of the tube, repeated in the plate circuit and heard in the headset. Two grid condensers are used, so as to have the advantages of the circuit shown in Fig. 2. Very good results are obtained from this circuit on a 25-mile range, and local stations are strong enough to operate a loud-speaker.

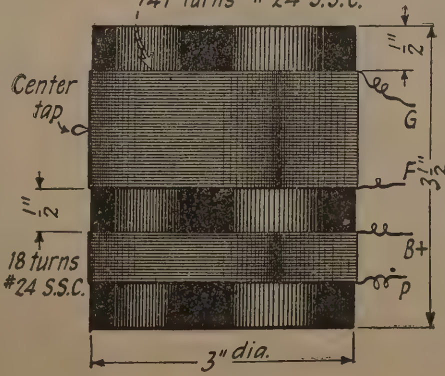


Fig. 1

Details of an oscillator coil used in some of the Super-Heterodyne circuits described in this issue. A center tap is provided on one of the windings so that the coil may be used in a Tropadyne circuit.

Super-Heterodyne Receiver

The usual super-heterodyne receiver employs eight or nine tubes. In our illustration, Fig. 10, we show a super-heterodyne receiver in which only one tube is used. The tube is connected as an oscillator for heterodyning the received signals. Two crystal detectors are used, one for detecting the beat note and the other for detecting the audio note. Very good results are obtained from this receiver when using a loop aerial. The construction of the oscillator coil G-F-B-P is shown in Fig. 15. Coils (L) may be of the honeycomb type of about 600 turns each. A variable condenser is shown connected across each of these coils. The experimenter may try fixed condensers instead of the variable condensers in this circuit. The disadvantage of this hook-up is that it is necessary to make two crystal detector adjustments, but with a little practice one can easily tune in a station. This circuit offers many possibilities of improvements.

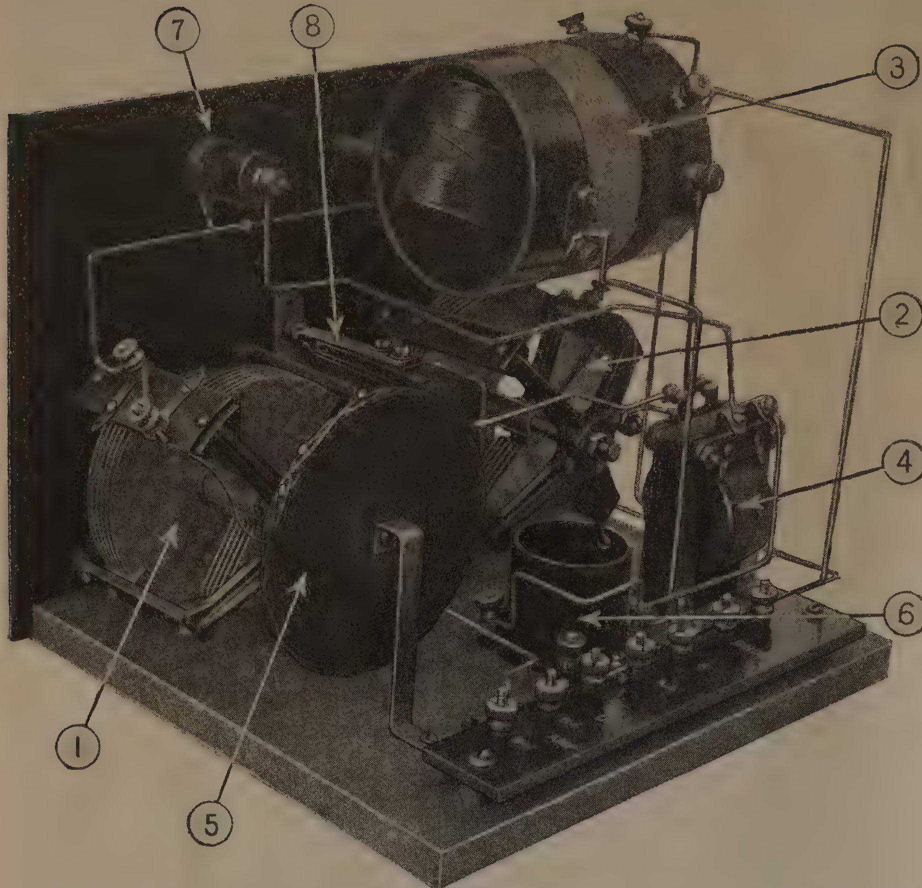
Reflexed Super-Heterodyne

Fig. 11 shows a hook-up that is similar to the one shown in Fig. 10, except that the output of the second crystal detector is fed into an audio transformer and amplified by the oscillator tube. The headset or loud-speaker is connected in the

(Continued on page 136)

Superdyning the Reflex

By R. Washburne



Rear view of the superdyned reflex receiver. The numbers designate the following instruments: 1, plate circuit condenser; 2, grid circuit condenser; 3, tuning coil; 4, audio frequency transformer; 5, plate coil; 6, socket; 7, crystal detector; 8, telephone jack.

HERETOFORE, to use a word time-worn but apropos, reflex receivers have been operated in such a way as to permit only a very low negative, or sometimes positive, bias on the grids of the tubes amplifying combined currents of radio and audio frequencies. The grid bias voltage control has usually taken the form of a "losser" (potentiometer). By utilizing the superdyne principle of negative feedback, oscillations are perfectly controlled, thereby eliminating the need of a detrimental potentiometer, and resulting in greater amplification. The apparatus given in the list will be required to build the set.

The photograph of the set indicates that the instruments will not fit in a standard cabinet, if mounted as shown. However, the layout used was entirely an experimental one. The panel used was seven inches high and ten inches long; it should have been 14 inches long. A longer panel would have permitted mounting the coupler between the two variable condensers. For that matter, a 12-inch panel would have permitted this, but it is of primary importance to have the grid and plate circuits well separated.

With one exception, standard equipment was used throughout. The spider-web plate inductance was that exception. A spider-web left over from previous experiments proved admirably suited to the existing conditions. Possibly a honeycomb would also have proved satisfactory; or any coil having equivalent characteristics. The spider-web was chosen in preference to other forms of inductance because of its small size. This reduced the effects of coupling to a minimum.

When working out the original design the following points had to be considered: (1) Low loss instruments; (2) crystal detector suitable for reflex work; (3) Non-inductive relation of coils; (4) simplicity of tuning; (5) high amplification at both radio and audio frequencies.

List of Materials

1 Ambassador variocoupler
2 Bruno low loss condensers
1 Foote crystal detector
1 Na-Ald socket
1 10:1 Audio frequency transformer
1 Phone jack
1 50-turn inductance, low external field type
1 Rheostat
1 Dubilier fixed condenser, .00025 mfd. capacity
1 Radion panel, 7×14
8 Eby binding posts
Bus wire sufficient

Each point was well met in the following manner: Double section condensers having losses too low to measure on most testing instruments, and having balanced plates, were employed. Litzendraht wound coils (including the spider-web inductance) were used. The audio frequency transformer has a 10:1 ratio. The variocoupler should have a rotor turning through 180 degrees; a crystal detector designed for reflex work was found best. The inductive relation of the coils is shown in the photograph. Only two tuning dials and one coupling control are required. High amplification was secured when a W. E. 216-A tube was used in the circuit. Heretofore potentiometers have been used to put a positive, or low negative, potential on the grids of the reflex tubes. A few sets eliminated the potentiometer by introducing other losses.

A positive, or low negative, bias of the grids results in very poor amplification at audio frequencies, and only fair amplification at radio frequencies. By utilizing the Superdyne principle the grids may be biased with from three to six volts negative. Still the set will not oscillate and the use of low loss instruments will result in maximum efficiency. The highest amplification from hard tubes is had with a high negative bias and a high plate potential. This ideal situation is realized in this receiver.

Very peculiar results have been observed during the various tests so far made with this receiver. The aerial was a composite one, approximating an "Inverted L" 125 feet long. Aerials greatly affected the results. Different tubes produced widely different results also. Using a standard storage battery tube with a plate voltage of 100 to 150 volts, excellent headphone reception was had from stations within a radius of 50 miles and more. Two Chicago stations were received during the initial tests. This was considered quite satisfactory for a single-tube set, but a surprise was in store for the designer and his associate investigators. When a Western Electric 216-A tube was inserted in the socket, in place of the low-consumption tube previously in use, signal strength increased greatly. Readjustment of the apparatus produced the surprise. The 11 o'clock program of station WNYC, an air-line distance of 25 miles, came through so strong that sufficient loud

(Continued on page 97)

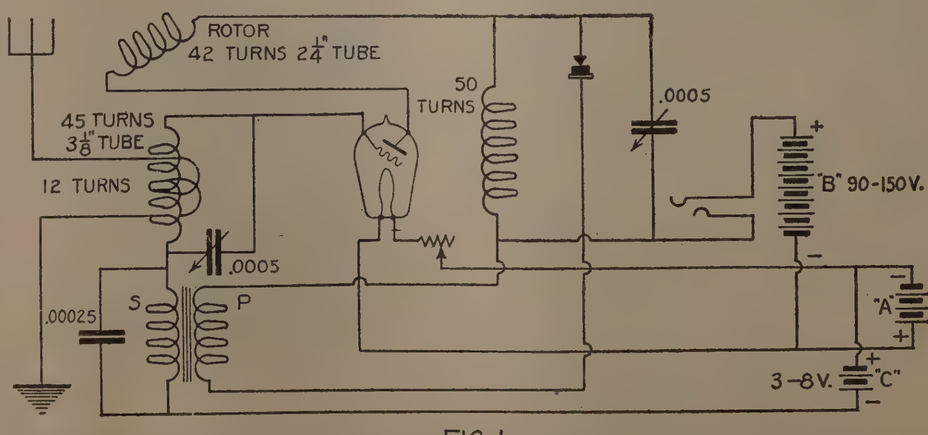
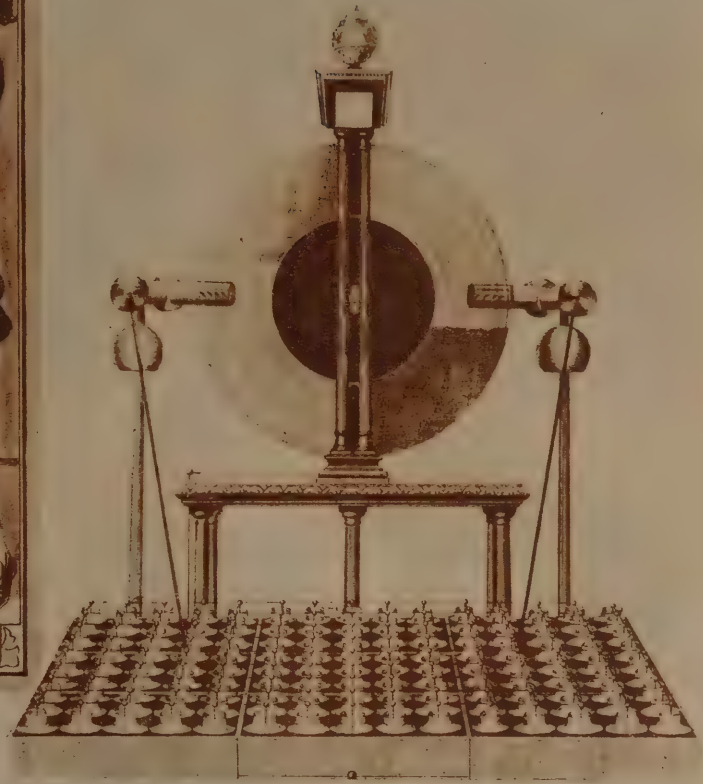


FIG. 1

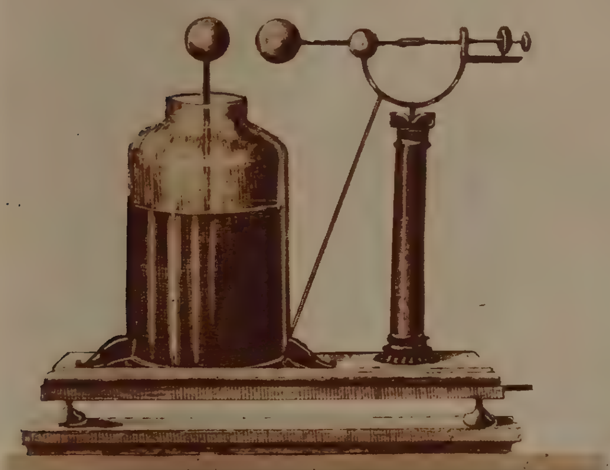
Circuit showing the connections of the superdyned reflex receiver. Note the 42-turn reverse feed back tickler for the prevention of oscillations. Experimenters may easily try this circuit on the hook-up board described elsewhere in this and the October issue.

Historic Experiments
No. 2
The Leyden Jar

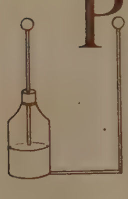
Pieter van Musschenbroek, in the University of Leyden, 1746, connected the water in an insulated glass vessel to a static machine. The vessel showed unexpected electrical activity when it discharged through the body of Cuneus, who attempted to remove the connecting wire from it.



Some years after van Musschenbroek's experiments, the University of Leyden installed the large static machine and battery of 135 Leyden jars shown above. The illustration is a reproduction of an old engraving from a book by Van Marum published in 1786.



This later form of the Leyden jar is provided with an adjustable spark gap whereby its potential can be measured.

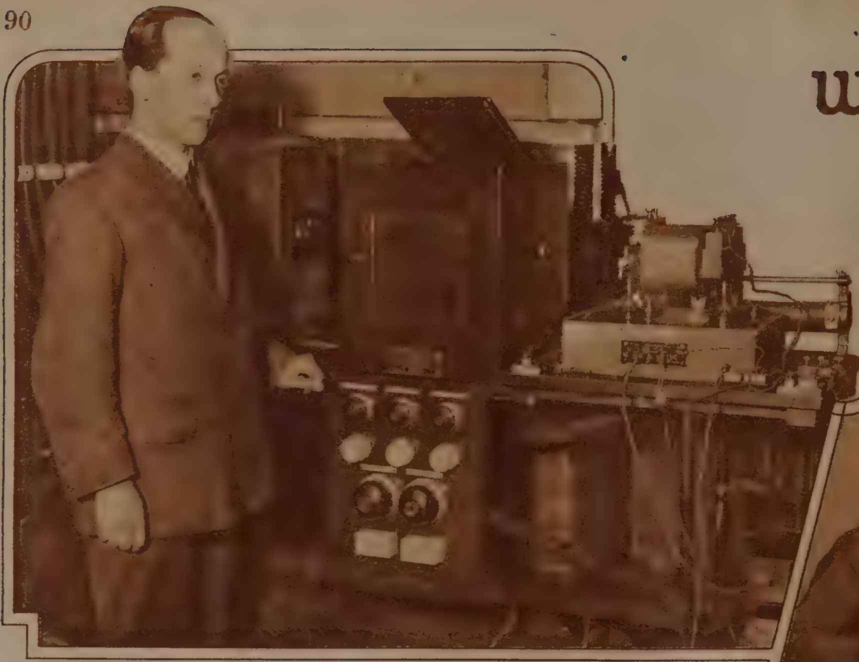


PIETER VAN MUSSCHENBROEK, a professor of natural philosophy in the University of Leyden, conducted, in 1746, numerous experiments in an attempt to accumulate electricity in insulators. The means for generating electricity were well known at that time, Otto von Guericke having, in the latter part of the 17th century, constructed the famous frictional electric machine, which was discussed in the preceding issue of THE EXPERIMENTER. But the methods of storing electricity were still unknown, until the experiments of van Musschenbroek, leading to the invention of the Leyden jar, which were so successful that Cuneus, a friend of the professor, who received the first shock from that little vessel, could not again be induced to approach it.

Since these early days the Leyden jar has been much investigated. Our own versatile Franklin has made important studies of its characteristics. It is the incipient form of the modern condenser, and has indeed been used in the form of small glass tubes with metal coating, in older types of the radio circuits. It directed the attention of scientists of the 18th century to the study of condensers. Among these scientists M. l'Abbé Nollet, a contemporary of van Musschenbroek, a physicist at the Court of France, did much to render electrostatic phenomena interesting to the layman. One of his whimsical experiments, illustrated on the right, is a fascinating demonstration of the electrical capacity of the human body.

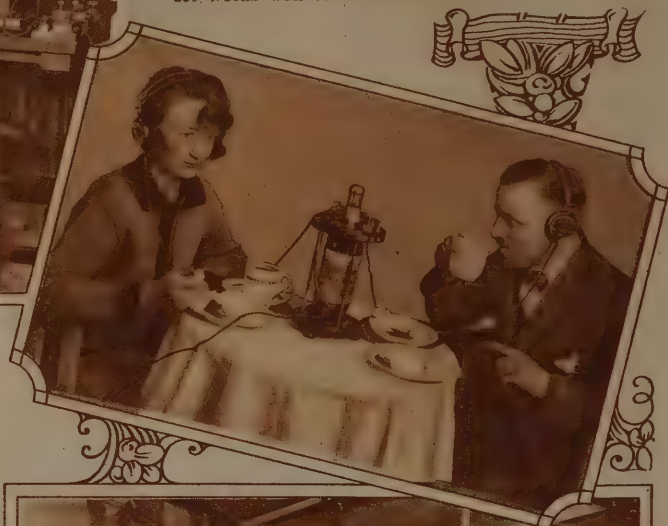
The human condenser, demonstrated by Nollet at the Court of France, is a boy insulated from the ground and charged with an ebonite rod rubbed with fur. When the body accumulated sufficient electricity sparks were drawn from it, and it attracted pieces of paper or other light insulating substances.

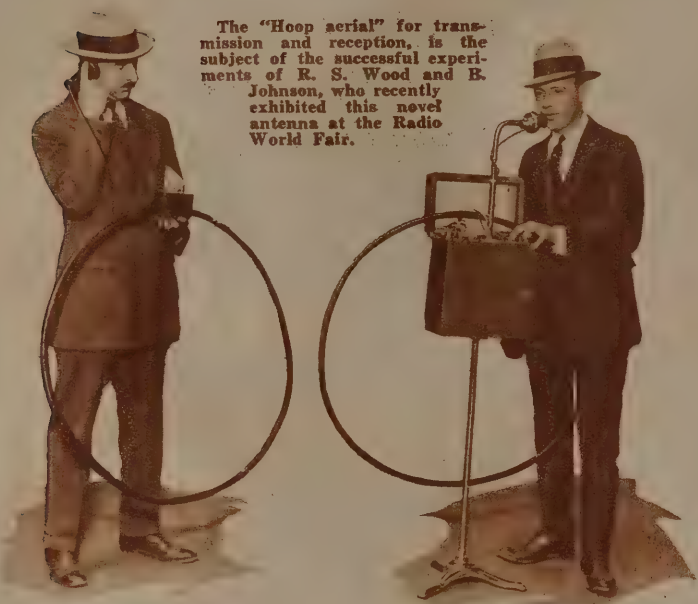
What Experimenters



A daring experiment will be attempted by Dr. T. F. Wall of Sheffield University, shown at left, who will attempt to disintegrate the atom. Such disintegration of an atom into its component electrons and protons liberates stupendous energy and if performed on a large scale may result in a world catastrophe.

Below: An efficient crystal set, reminiscent of pre-prohibition days, was built by an ingenious experimenter who wound his coils on a cognac flask. The set works well on local stations.



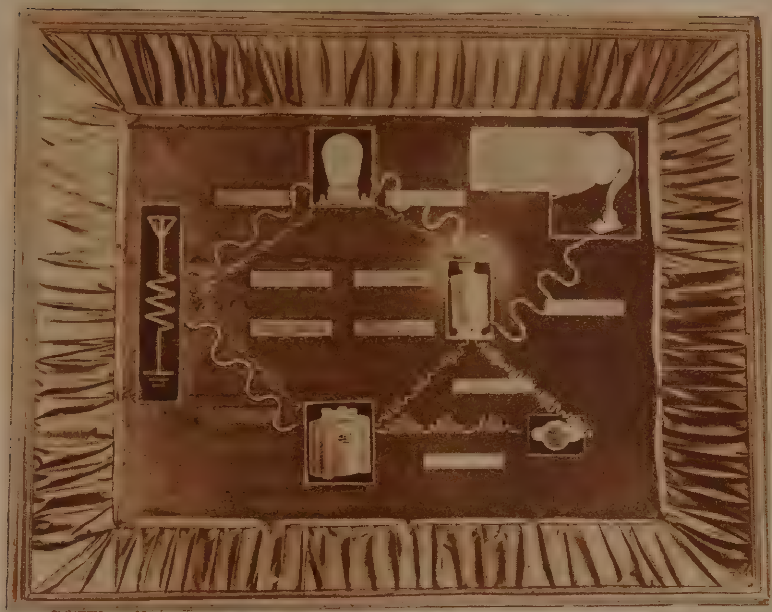


The "Hoop aerial" for transmission and reception, is the subject of the successful experiments of R. S. Wood and B. Johnson, who recently exhibited this novel antenna at the Radio World Fair.

Due to the extremely low temperature required, attempts to liquefy helium gas have proved unsuccessful until Prof. J. C. McLennan of the University of Toronto, Canada, with the apparatus shown above, succeeded, after two years of patient experimentation, to reduce the gas to a liquid at a temperature of 269 degrees Centigrade, below zero.

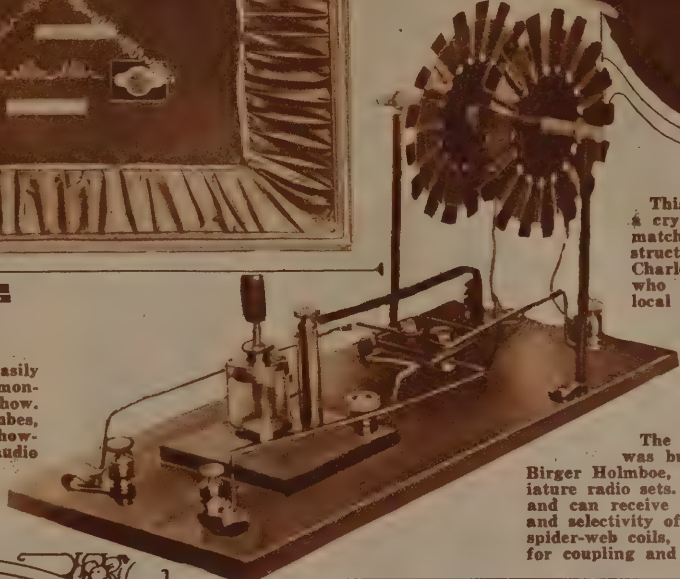
Electricity in the service of the embalmer is illustrated at the left. The dead body, placed inside the large retort, becomes dehydrated by electrically produced heat and the electrolytic action of a current passing through the body.

Are Doing Today

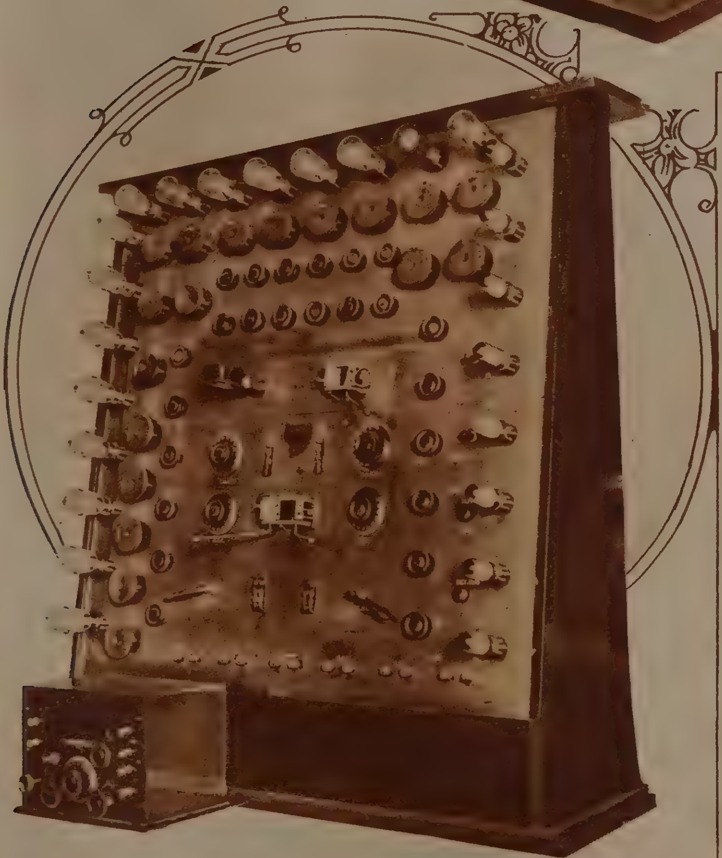


The operation of the reflex circuit is easily understood by the aid of this electrical demonstration board used at the Chicago Radio Show. The oscillations are represented by neon tubes, which become successively illuminated, showing the various stages of both radio and audio amplification and detection.

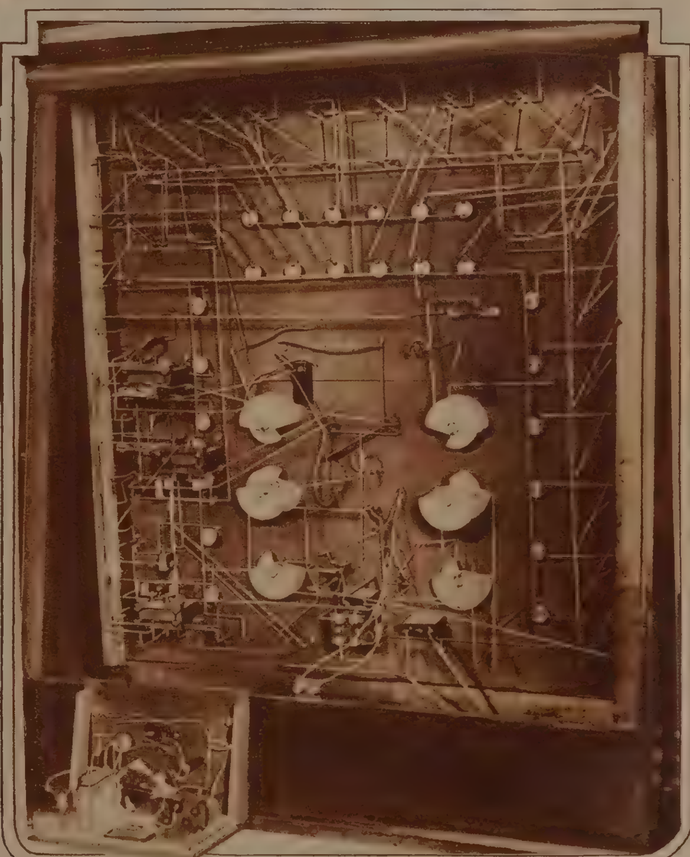
This thimbleful of radio apparatus is a crystal receiving set that fits into a matchbox—and works! It was constructed by a young experimenter, Charles Allen, of Alameda, California, who used it successfully in receiving local stations.



The small crystal receiving set at the left was built at a cost of only $3.15 by Dr. Birger Holmboe, known for his experiments on miniature radio sets. This set will fit into a coat pocket and can receive stations within 25 miles. Efficiency and selectivity of the set are obtained by the use of spider-web coils, which may be moved along the rod for coupling and tuning.



Six months of patient research on the part of British radio engineers have resulted in this 24-tube radio receiving set, specially designed to pick up communication from Mars. Compare with the ordinary two-tube set at left.



The interior view of the 24-tube receiving set displays unexcelled neatness in construction. In this respect, as in efficiency, the two-tube set at the left compares unfavorably with it.

The Ark of the Covenant

By Victor MacClure

"This is mighty interesting, Jimmy—mighty interesting. I never heard of anything to tarnish gold in this way."

(What Has Gone Before)

The president of a bank, stern business man, stands by his son's bedside early in the morning and wakes him. Instinctively he realized that something was wrong, and jumped out of bed.

Seeing that his father was in deadly earnest, no questions were asked, but with his roadster and airplane he undertook to rush him to the city. The story is far in the future. In the gray March morning the Battery was soon reached at a rate of 159 miles per hour.

Going up Broadway every step showed that something strange had happened. The watchman at the bank acknowledges that he was asleep, and it gradually develops that sleep pervaded the district. The vault door had been opened by oxy-acetylene or some strange device that cut through panels and knobs. The watchman pulled out his watch to tell the time and finds it coated apparently with verdigris. The policeman, too, has been asleep. When this installment of the story closes, the case is a more involved mystery than ever.

Four other banks, it seems, had been robbed. Guards and watchmen had been asleep. Some mysterious method was used to burn open the safe, and the oxidation of the watch added to the mystery and brought it into the realm of chemistry.

One of the policemen recovered consciousness and found he had been lying asleep on the sidewalk, and in a doorway he found his own inspector overcome by the same unconsciousness. The mystery is at its height.

"SAY!" he yelled. "What do you know about this, eh? Were you eye-witnesses?"

"As far as I can see," Dick told him, "eye-witnesses are just what there aren't."

But he shot a quick account of what he had heard to the little man, and advised him to get after the foot police and the watchmen of the banks. The little man wanted nothing so much as a reasonable theory to explain the success of the raid, but we wanted that just as much as he did, and he went off with an openly exhibited contempt for our lack of imagination.

Still a Mystery

The further we went, and the more information we acquired about the affair, the thicker grew the mystery of it. The central fact was this—and all else was relatively unimportant in the face of it: that for two hours of the morning, between three and five, the financial district of New York had been peopled by men who, whether doped or otherwise rendered unconscious, might to all purposes have been dead, for all they saw. There was no clue to the identity of the gang that had contrived to break into five of the greatest banks in the city and get away with a fortune in gold and easily negotiable scrip. I heard that a finger-print had been found in one of the banks. But I imagined it would need more than that to lead to the recovery of what was then reported to be a staggering loss.

I had a talk with one of the policemen who had been in the district during the lost hours. In a general way I got nothing that was fresh out of his account, but he was a big Irishman who made me laugh with the unconscious humor that ran through his conversation, and I spoke with him long enough to get quite friendly with him. I was leaving him, to turn back and see how my father was faring, when suddenly I remembered something.

"By the way," I said to the big fellow, "do you happen to have about you anything made of gold—a watch or a trinket of any sort?"

He grinned sheepishly behind a big hand.

"I've a bit of a locket," he said, "with a photy av the girl in ut. She makes me wear ut next me heart. Don't laugh, an' I'll show ut to ye—"

I gave him my promise not to laugh and he produced the trinket from under his tunic. He was much more surprised than I was to find it tarnished to a dull brownish green.

CHAPTER TWO

Clues and False Leads

I

It was round quarter past eight o'clock when I got back to the National Metallurgical. I found it difficult to realize that only an hour had passed since I had landed with my father at the seaplane jetty on the west side of Battery Park, and I had a feeling that the time should have been close to noon at least, for the hour had been crammed with incident and impression.

A number of the bank executives had arrived, and the place already had a flustered air of activity. The chief accountant was with my father, and I judged by the look of him that he was a very scared man. Apparently he and the president had been calculating the bank's losses, for as I came into the room the old man drew a firm line under two rows of figures he had written on a small piece of paper.

The Bank's Losses

"A good haul, Risbridger," my father was saying casually. "Two hundred and fifty-three thousand, five hundred dollars in gold. Two hundred and thirty-four thousand, seven hundred in securities. But God knows why they didn't take all we had. You had better see about broadcasting the descriptions and numbers of the securities, and inform the police. If the thieves have not succeeded in getting out of the country, we may get a line on them, should they attempt to dispose of the scrip. See to this at once, will you?"

The white-faced official scurried away, glad to have something to occupy his mind, and my father turned to me.

I told him everything I had picked up, and he listened without comment until I had finished.

"M'm," he said. "That's a queer thing about the gold tarnishing. What do you make of it, son?"

"I don't know quite what to make of it," I told him. "My mind somehow connects it with whatever was used to dope the watchmen and the police. The stuff would have to be distributed in such a way that its fumes could be breathed.

The whole affair has such unusual features, it might even prove that if we were to discover what had sent everyone to sleep, we might land on the thing that tarnished Jaxon's watch and the policeman's locket. I don't know of anything that has such an effect on gold, nor of anything capable of producing the anesthesia. I'm inclined to think some sort of gas was used. The first difficulty we're up against is that none of the sufferers were conscious of even the slightest smell."

A New Gas

"Whew!" my father whistled. "A new gas, eh? If you're right, Jimmy, we're up against a big thing. When a gang of crooks can put the whole of the Wall Street district to sleep and get away with it, can you prophesy where the game finds its limit?"

"It opens up limitless possibilities," I agreed.

"There's no saying where this morning's work will end," the old man mused. "As it stands, if the other banks have been as easily entered as we have, there's the makings of a fine old panic."

"If there's going to be ructions, dad—don't you think you'd better meet them in comfort? What about a bath and breakfast?"

The old man surprised me by letting out a sudden little laugh, with a queer note in it, as if some hidden chord in his memory had been struck.

"You're like your mother, Jimmy," he said, after a pause. "You have her fair hair and gray eyes, and when you said that—I could fancy it was she who spoke. You see, son, life was pretty full of ructions in the old days, and you said the very thing she would have said when trouble was brewing. You don't remember your mother?"

I shook my head. My mother died when I was an infant, and I had never created any definite picture of her, to a great extent because my father seldom spoke of her. I expect it was that he missed her too much. She had been dead close on thirty years, but I could see, even then in his presidential room, how much she still meant to him. He looked at me queerly, and I have never seen him so softened either before or since.

"No," he said slowly. "You were only a very little fellow when——"

He broke off and lifted his shoulders in a sigh.

"You're right," he said. "Breakfast's the idea."

I anticipated that by this time there would be a jam in the subways and on the street cars, and as I wanted him to have as little physical exertion as possible, I telephoned for an automobile. While we waited my father issued instructions for carrying on in his absence.

When the car came, we rode uptown through the rapidly filling streets to a quiet hotel where he would not be recognized, and we both had a bath and shave before breakfast. I was wishing now that I knew enough about banking to stand by during the crisis I felt was imminent; not that I fancied my father could not stand alone, but I think my wish came largely out of the new realization of how much I cared for the old man. I wanted to be of some assistance, but I did not know just how. I spoke to him about it as we were finishing breakfast.

"Look here, dad," I said. "I want to stand by. I can be of no use to you on the banking side, but I could be a fairly good watch-dog. If I can do anything to keep troublesome people off you, or if I can run errands or attend to the commissariat—just say the word. I'll do anything I can."

Assignment of a Research

"I know that, son," the old man smiled, "but I'm well supplied with watch-dogs and messengers, who know my ways. No. Listen. I'll give you better than that to do. My hands will be full of the complications that are bound to rise from this raid on the banks, and I won't have time for anything else. In that tarnishing of the gold idea you've hit on something that maybe will give you further ideas, and I'd like you to follow up your theory of the gas and see what it leads to. You're an engineer, and you'll attack the problem from a different angle from that of the average detective. You can have a free hand in the matter of expense."

The old man's suggestion almost took my breath away, and I fancy my face got red. I must explain that while my father and myself had been good enough friends up to this, our ways had lain very much apart. He was devoted to his banking business, and I was immersed in aeronautical research. There had been times when we did not meet for months, and when we came together again it had simply been, "Hullo, Jimmy!" and "Hullo, dad!"—pretty much as if we had parted overnight. I knew all right what I thought of him. What he thought of me had been another story. That he had a good enough opinion of me to hand me a job of this sort, and give me the run of his purse, with it, put me in such a way that I could only nod acceptance.

(Continued on page 130)

"Five lead cases with extremely thick sides! . . . I am inclined to think some outrage is contemplated, I should say—explosives."

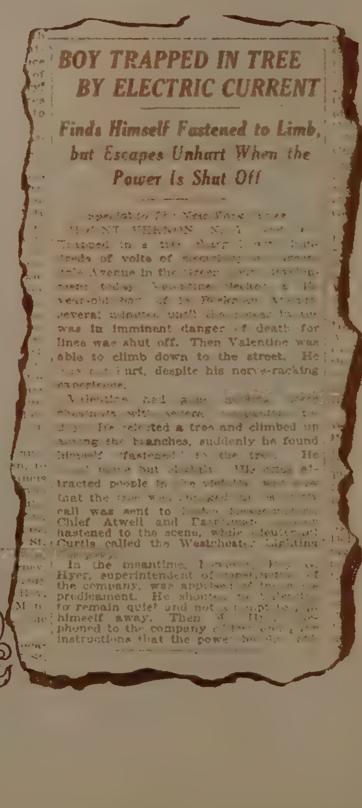
Largest Electric Clock

The picture above shows the hoisting of the hour hand of the huge clock being erected on the roof of the Colgate factory in Jersey City. This colossal clock, with its movement weighing four tons and run by a small one-quarter horsepower electric motor, is replacing the old clock shown at right. Note that in place of figures large rows of electric lights are used on the dial.

The Brobdingnagian Colgate clock, whose hands are shown at the right, is the largest electric clock in the world. The hour hand is 18 ft., and the minute hand 24 ft. long, each weighing 2,200 lbs. and carrying over 200 electric lights.

Odd Electric Accident

A strange case of electrical paralysis occurred to a young boy who, in climbing a tree, suddenly received a shock and was unable to release the branches he was holding. Investigation showed that a branch bending under his weight caused contact between an electric lighting main and a guy wire attached to the tree. The tree being a good conductor, some current passed through it and was received by the boy, who thus sustained part of the 7,000 volts between the lighting main and the ground.



BOY TRAPPED IN TREE BY ELECTRIC CURRENT

Finds Himself Fastened to Limb, but Escapes Unhurt When the Power Is Shut Off

[illegible] dreds of volts of [illegible] Avenue in the [illegible] several [illegible] was in imminent danger of death for [illegible] lines was shut off. Then Valentine was able to climb down to the street. He [illegible] hurt, despite his nerve-racking experience.

Valentine had [illegible] He selected a tree and climbed up among the branches, suddenly he found himself "fastened" to the tree. He [illegible] tracted people [illegible] that the [illegible] call was sent to [illegible] Chief Atwell and [illegible] hastened to the scene, while [illegible] Curtis called the Westchester Lighting [illegible]

In the meantime, [illegible] Hyer, superintendent of [illegible] the company, was apprised of [illegible] predicament. He shouted [illegible] to remain quiet and not [illegible] himself away. Then [illegible] phoned to the company [illegible] instructions that the power be [illegible]

Up-to-Date EXPERIMENTERS

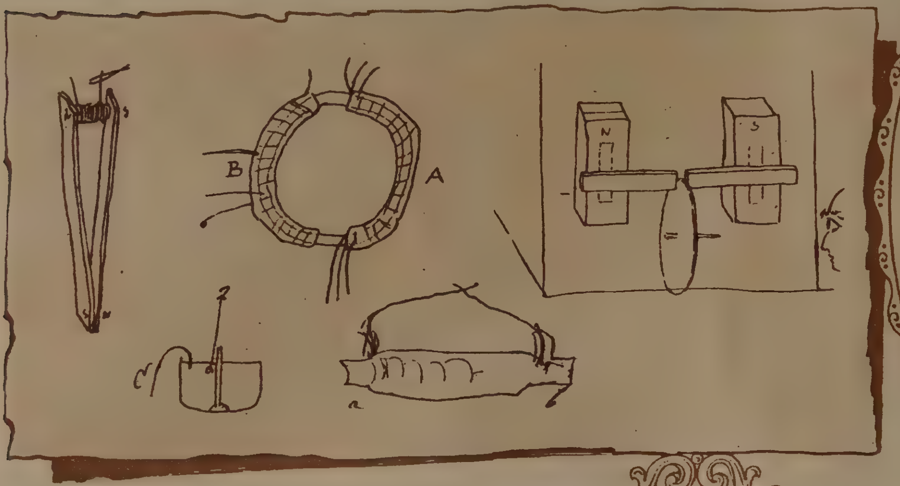
A happy union of culinary science and the more exact science of electrical engineering has contributed much to the success of Miss Ethel Peyser's electrical household inventions. Her present experiments concern the home generator shown below.

Confronted with a difficult dilemma in the course of her experiments, Miss Mary Texan Loomis—the first woman to conduct a radio school—has recourse to the infallible powder-puff.

Directed transmission, while still in its experimental stage promises success with this parabolic reflector for radio waves; devised by Marconi.

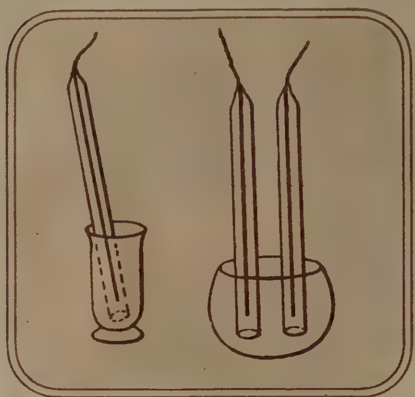
Persistent experimentation has led to the complete elimination of interference by means of this "vertico-horizontal" loop antenna which achieves perfect selectivity by a combination of vertical and horizontal loops.

A Famous Experimenter



Faraday's notebooks are replete with ideas. The sketches above are reproduced from his notes on some of the experiments illustrated on this page. They show a remarkable fecundity of imagination.

Michael Faraday, the father of experimental electricity, is the discoverer of the phenomena at the foundation of the electrical industry today.

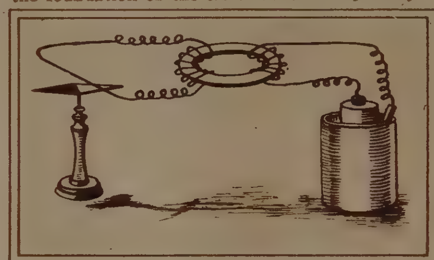


Many of Faraday's experiments were concerned with electrolysis. His apparatus for decomposing water embodies the unusual feature of introducing the electrodes at the sealed top of the tubes, rather than through the open bottom, as done by modern experimenters.

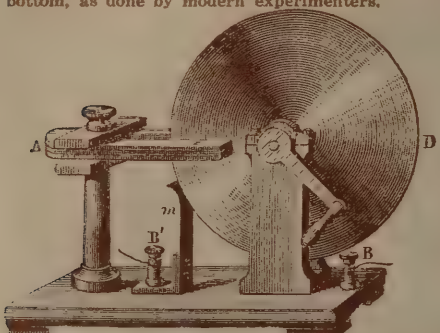
Michael Faraday

The far-reaching electrical applications that characterize the modern industrial civilization are a tribute to the genius of Michael Faraday, who did more than any other individual to elevate electricity from the state of trivial experimental amusement to the position of a great and comprehensive science. That he was the son of a blacksmith, with not even the opportunity of an elementary schooling, testifies to that thirst for knowledge and the inexhaustible energy that enabled Faraday to become the world's foremost experimental scientist. To a lesser man, his most important experiments, illustrated on this page, would have seemed insignificant in their bare simplicity, but in the eyes of Faraday, who in experimental data could see the soul, the inner essence of facts, they assumed a vital importance. Just as his experiments were characterized by a striking and beautiful simplicity, so his manner of expression in writing and lecture was lucid and precise; a modest inornate style, made beautiful by the vision that prompted it. Throughout his long and full life, research formed a sustaining and engrossing interest, a vital urge to probe into the mysteries of Man's environment.

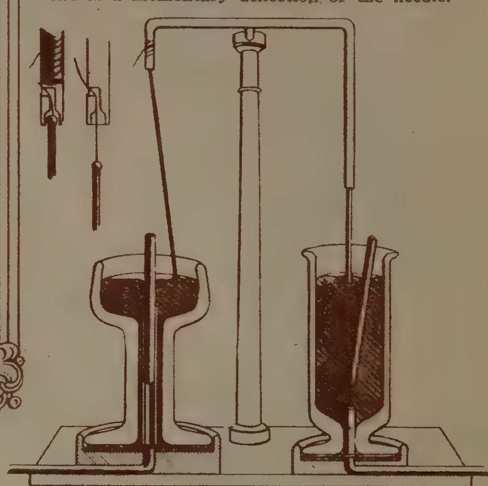
He was born in England, 1791, and at an early age was apprenticed to a bookbinder. Fortunate circumstances brought his remarkable ability to the attention of Sir Humphry Davy, under whose patronage he became the director of the laboratories of the Royal Institution, where he did most of his valuable work. His death in 1867 terminated one of the most productive, most important lives in the history of civilization.



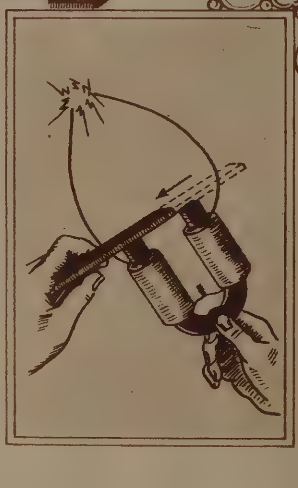
An incipient form of the transformer was constructed by Faraday in his study of electromagnetic induction. Upon closing the battery circuit a current pulse induced in the secondary causes a momentary deflection of the needle.



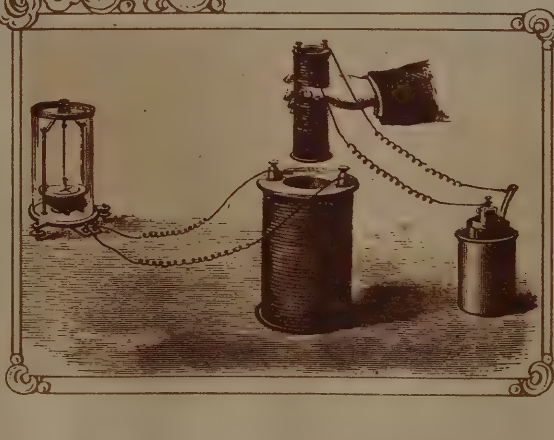
The modern generator is the industrial outgrowth of the simple experiment illustrated above. The permanent magnets induce electromotive force in the metal disc rotating between its poles.



The huge electric motors of the present day are material expressions of the principles involved in the experiment illustrated above. The electromagnetic reaction between a permanent magnet and a wire, carrying an electric current, and dipping in mercury, causes rotation of the wire in the apparatus at right and of the magnet in the vessel at the left.



Faraday's primitive spark coil! A change in the magnetic field caused by the sudden motion of the permanent magnet induces an electromotive force in the coil and sparking at the terminals results.



Electromagnetic induction is illustrated strikingly by the famous Faraday experiment shown at the left. The small coil carrying a current induces a current in the large secondary when dropping into its core. The secondary current is indicated by the galvanometer at the left.

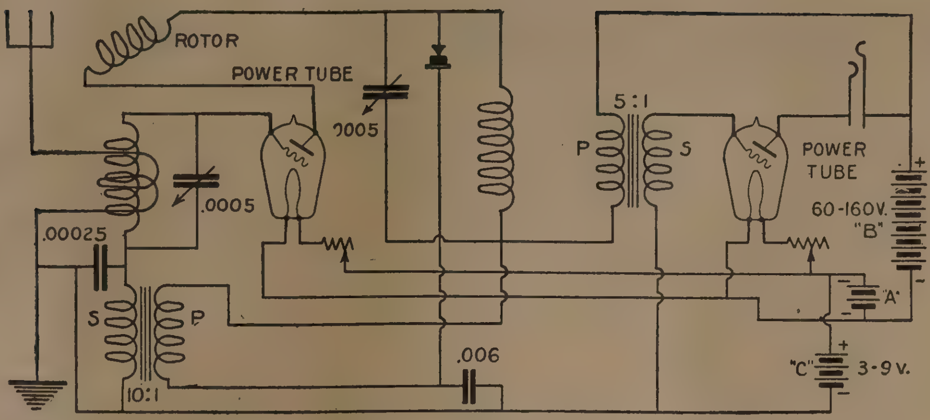


FIG. 2

Above—The superdyned reflex receiver with one stage of A. F. amplification. Under proper conditions this circuit gives as much volume as the ordinary three-tube receiver.

Below—An improved circuit in which the crystal is inductively coupled to the plate coil. By using the proper ratio R. F. transformer very good results are obtained. Note that a step-down ratio seems to work better with a crystal.

speaker audibility was obtained to make the program clearly heard on the second floor (set being on the ground floor) of the building in which most of the tests were made. Further tuning brought in four or five other stations at greater distances, also on the loud speaker, but with reduced volume, of course.

The writer will be pleased to give further information on the above or following points which may not be clear.

Of course, there may be considerable room for improvement of this circuit. A few of the variations of this circuit, which the experimenter will want to try, are shown. Fig. 1 is the original circuit. Fig. 2 is the same circuit, with one stage of audio frequency amplification added. Fig. 3 shows a little variation in the coupling unit which may result in sharper tuning of the plate circuit, which otherwise was found to tune broadly. This was not a disadvantage, due to the sharp tuning of the grid circuit.

A blocking condenser was tried in series with the crystal detector in order to prevent the D. C. plate current from passing through the crystal circuit. Plate tuning was not greatly sharpened by this arrangement. Adding radio frequency amplification will increase the range and adding audio frequency amplification will increase the volume. No rheostat was used in the experimental set, since there was one in the current supply line. The standard variable condenser symbol has been made to indicate proper connection by showing the arrowhead on the rotor plate side of the condenser. This practically eliminates capacity effects. We wish to point out that pyrotex fixed crystal detectors operate splendidly in this receiver, requiring no adjustment.

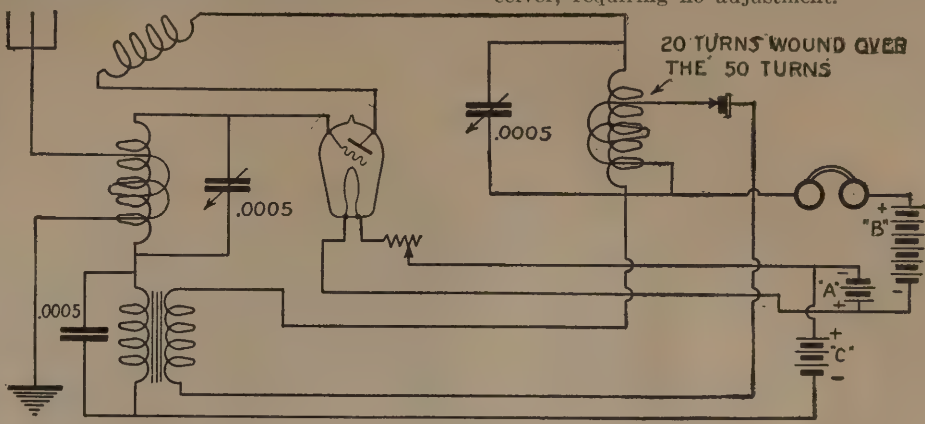


FIG. 3

Simplidyne Circuit

By Aurelio L. Fernandez

IN view of the great quantity of receiving circuits, more or less efficient, which have been published and are known by the public, a new one would have no reason for announcement if it did not combine positive advantages over the others.

The following circuit is the most economical of all known, and in a few seconds can be adapted to existing single or double circuit receivers; simply short circuit the grid condenser and disconnect the terminal of the A battery from the ground. The variable resistance can easily be made or a satisfactory one obtained in the stores, taking the precaution of not using a combined variable leak and grid condenser.

It is immaterial whether the primary coil and the tickler coil are of the standard vario-coupler, or spider-web form, but if you wish to have a wide range of wave lengths the primary should have taps; the tickler coil has no taps.

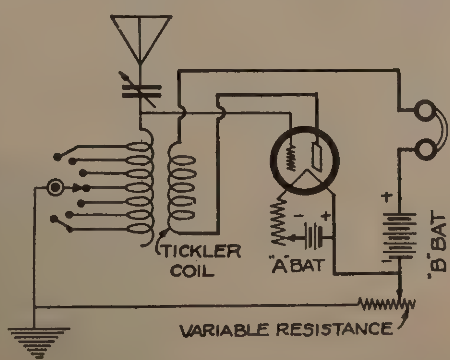
It is convenient that the tube shall be hard like the 201-A, but any kind of tube works. In my experiments I used a 201-A and a W. D. 11, always with better results than with the same tubes used in ordinary regenerative circuits. A W. D. 12 dry cell tube is recommended.

The head-set should be connected between the positive terminal of the B battery and the tickler. A bypass condenser is not required. The Baldwin C and the N. K. head-sets work good. Various experiments should be tried for reasons which will be explained in another article.

A variable .0005 mfd. antenna series condenser is used. The voltage of the B battery, storage battery or dry battery is that which corresponds to the type of tube used.

It must be taken into account that while tuning in a transmitting station the variable resistance which I describe below should not be used. Only when the maximum of clearness is to be obtained may we think of using it.

If the circuit is unstable while tuning in a station and the volume increases or diminishes with the approach of the hand or movement of the body, or of the tickler coil, or the sound is not clear, it indicates that the circuit is oscillating and the primary switch tap should be changed.



The simplidyne circuit, which is similar to the ordinary single circuit receiver except that no grid condenser is used and a high variable resistance is connected between the filament and the ground. Remarkable results are claimed from this receiver.

I have in the preceding written with detail to prevent amateurs from having a disinclination to the principle; in general, the adjustment is easy, moving simultaneously the antenna connection and the tickler coil.

It is possible to receive long-distance transmission, but I have no data as I have no antenna adapted therefor. I hope that some amateur will tell what results he obtained.

If one wishes to use an extra stage of amplification with a transformer, a separate B battery should be employed. The filament current is critical, just as in every-day circuits.

The amplification of the circuit which I describe is obtained by the variable non-inductive resistance, which I have made in the usual form of a grid leak using a common No. 2 pencil and a little piece of insulating fibre. One end of the resistance is connected to the ground by a conductor and the other end is free.

In connecting the positive pole of the B battery with one of the terminals of the telephones the movable tap of the resistance may rest upon the grounded end. I repeat that while tuning in a station the resistance should not be used, nor in weak stations except when it is desired to obtain extra resistance coupled amplification. It is a question of experimentation.

If clear reception is not obtained, the movable tap is placed on the resistance; if the volume is the same or increases, the maximum of rendition should be striven for; in practice the movable tap is slowly pushed to the other extreme, and as each movement is made the tuning should also be changed slightly, moving the antenna condenser and the tickler coil. As the intensity increases tuning is more critical. In general this is easily carried out.

Experimental Radio Frequency Circuits

By W. L. Pearce

WHEN the itch for distance overcomes the experimenter he naturally turns to radio frequency amplification. Figuring that one stage should increase the receiving range, a new circuit with this addition is tried. After working on the set for a few nights it is found that the range remains as before. The long-distance stations are as elusive as ever, and in disgust the old reliable regenerative receiver is again put into operation.

It is difficult for the novice to understand why this is so. If radio frequency amplifies the signal before it reaches the detector, then why does not the addition of one stage of R. F. amplification improve the distance reception of the receiver?

Some types of radio frequency amplifiers, if correctly used, will give a noticeable increase in efficiency, but others will, if anything, give poorer results.

It must be remembered that when a standard R. F. transformer is employed regeneration must be sacrificed, and as regeneration is in itself equal to one stage of R. F. amplification, it will be evident that no advantage will be gained by using only one stage. A diagram of this circuit is shown in Fig. 1. A potentiometer is usually employed to keep the radio frequency tube from oscillating. If the potentiometer lever can be moved completely to the negative side without the tube oscillating, the potentiometer is not necessary and may be discarded. In this case, the grid return of the R. F. tube is connected directly to the negative "A" battery lead.

The main disadvantage of using an R. F. transformer is that it has not been possible to design a transformer that will amplify equally well on all wave lengths. There is a certain wave length on which the amplification will be at maximum, and above and below this wave length the amplification will fall off. This will be understood when it is explained that a radio frequency circuit must be tuned to a given station, and as a transformer has a certain natural wave length, it will, of course, function best at this point. Radio frequency transformers are wound with fine wire having a large resistance to broaden the tuning so that it will take in a wider band of wave lengths. This naturally decreases the efficiency of the transformer at all wave lengths, even at the one on which it functions best. Some manufacturers make different transformers for each stage. The first stage transformer may be designed to be most efficient on 300 meters, the second transformer on 400 meters and the third on 500 meters. It will thus be seen that amplification will be nearly equal from about 250 to 550 meters. This system, although giving the same amplification on a wide band, will be lower in efficiency than if all stages could be tuned to any desired wave length.

As regeneration cannot be used and as the transformer must be broadly tuned, it follows that a tuner must be employed that is selective. Such a tuner should be so designed that the coupling between the primary and secondary may be made very loose. The coils should also be wound with large wire, not smaller than No. 20, and preferably double cotton covered. A condenser of good manufacture and of the low loss type should also be used.

A more efficient form of R. F. amplifier is shown in Fig. 2. This is known as a tuned impedance amplifier. It includes an inductance in the plate circuit of the R. F. tube, tuned by a condenser. This inductance may consist of 48 turns of No. 22 S. C. C. wire wound on a three-inch tube. By means of the condenser the coil can be tuned to any station and amplification will be at maximum at any wave length. As the plate circuit is tuned to resonance with the grid circuit, the tube will naturally oscillate and a potentiometer is essential. Whenever a potentiometer is used a filament switch should be employed, as otherwise the potentiometer would always be consuming current, even when the tubes are turned out.

This type of R. F. amplification will prove quite selective and when carefully operated will bring in numerous distant stations. It will be found that for maximum results the potentiometer lever must be shifted for every change in wave length. As the lower waves are tuned in the lever must be moved closer to the positive side to prevent the tube from oscillating. Instead of the plate coil and condenser, a standard variometer may be used with good results. The coil and condenser, however, are recommended, as with this combination the tuning will be sharper.

Regeneration may also be obtained in the detector circuit by inserting a coil (L^1) in the plate circuit and placing it in inductive relation to the tuned impedance coil (L). These coils may take the form of the primary and secondary of a standard variocoupler. Only enough of the primary turns should be used to cover the desired wave length band. With this arrangement slightly greater volume can be obtained if the set is correctly tuned. However, it is doubtful if regeneration is of much advantage in this circuit, as the action of the tickler coil affects the tuning of the radio frequency circuit and makes accurate tuning very difficult. An increase of regeneration also brings the R. F. tube closer to the oscillation point, and if the potentiometer has been set for maximum signal strength the tube will break into oscillation, thus necessitating further adjustment. A variometer in the plate circuit, in non-inductive relation to

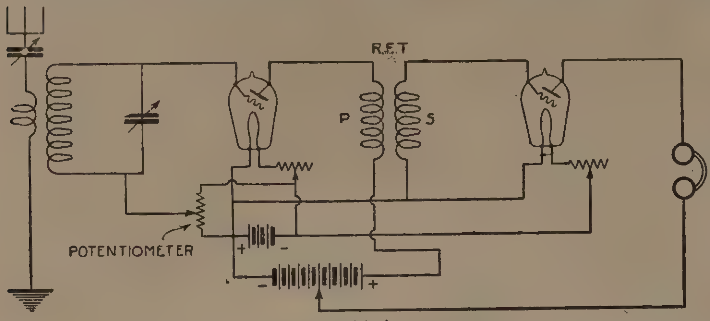


FIG. 1

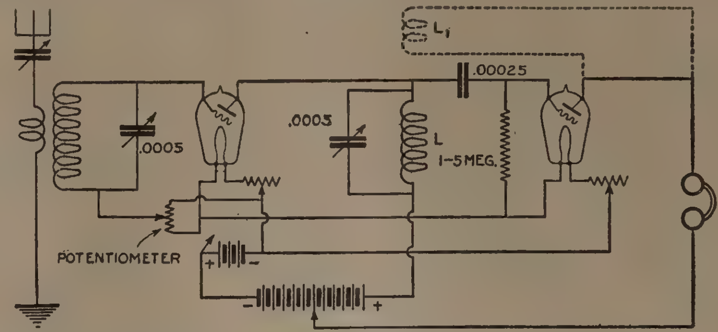


FIG. 2

Left—A radio frequency amplifier employing a fixed R. F. transformer. A potentiometer is used for stabilizing the circuit and preventing oscillations. Right—A radio frequency amplifier employing a tuned impedance instead of a R. F. transformer. The dotted lines indicate a connection for obtaining regeneration in the detector circuit.

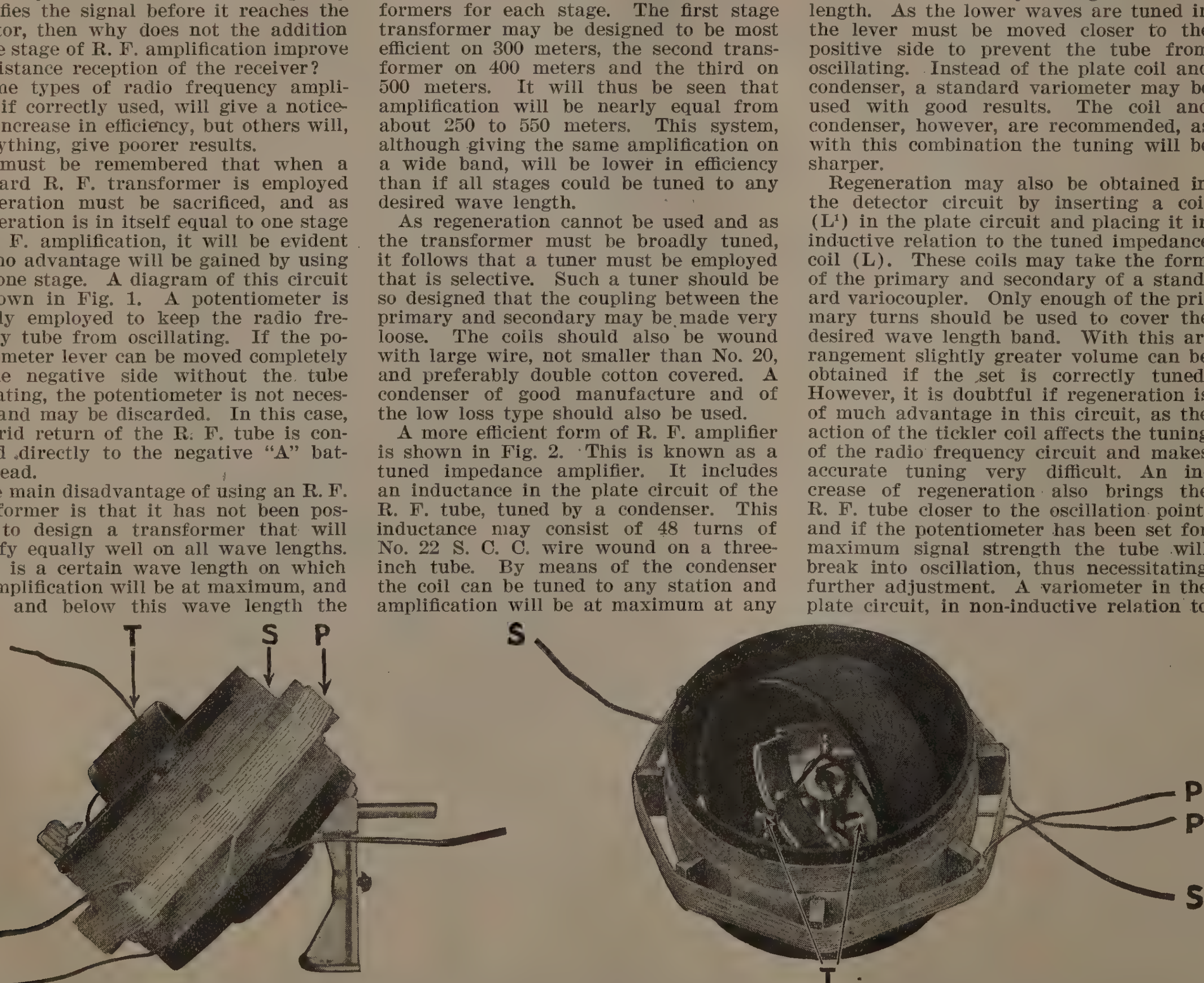


Fig. 5. An untuned primary coupler that has given excellent results in Mr. Pearce's experiments with radio frequency amplifiers. Note how well the primary is spaced from the secondary so as to reduce electrostatic coupling between the two windings.

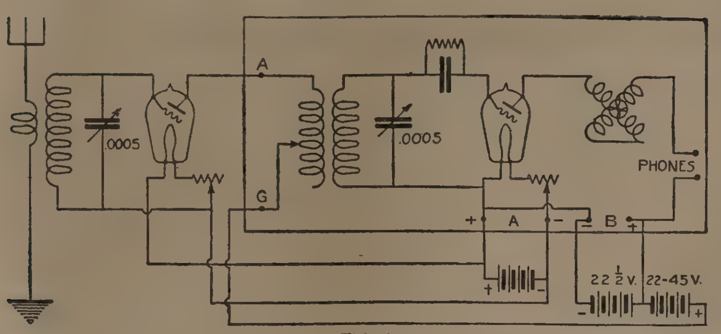


FIG. 3

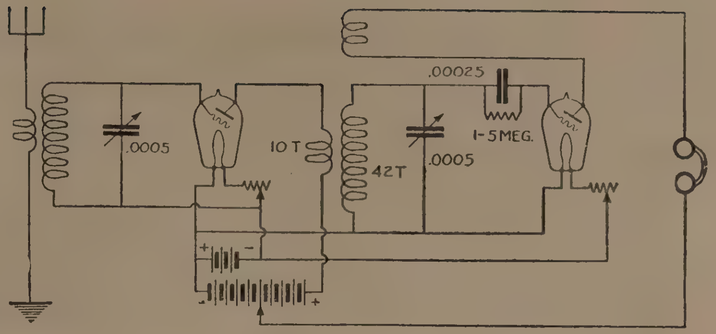


FIG. 4

Left—Circuit showing how one stage of radio frequency amplification may be connected to a standard three circuit receiver. In this case the variocoupler of the standard set is used as a tuned R. F. transformer.

Right—A radio frequency amplifier circuit similar to Fig. 3, except that regeneration is obtained in the detector circuit by means of a tickler coil. This is the most efficient method of obtaining radio frequency amplification and a standard three circuit tuner is used for coupling the two tubes.

the tuned impedance coil, would perform better, as it would not directly affect the radio frequency circuit.

It often happens that one stage of radio frequency is desired with a standard three circuit receiver. A radio frequency transformer cannot be employed, as it would have to be inserted between the tuner and the detector, which would mean that the whole set would have to be completely rewired. The obvious solution is to place the radio frequency stage before the set proper as shown in Fig. 3. If a series condenser is not employed in the original set, and if the filament is not grounded, no changes at all will have to be made in the receiver. If a series variable condenser is in the primary circuit it must be removed or shorted, otherwise the "B" battery circuit of the R. F. tube would be open and the set would not function. It will be noticed that no transformer of any kind is employed, as the original variocoupler serves as a tuned radio frequency transformer. The plate of the amplifying tube is connected directly to the antenna binding post and the ground binding post is connected to the positive of the "B" battery. Anywhere from 45 to 90 volts may be used for the plate of the amplifier. The same "A" and "B" batteries are employed for both tubes. If, in the original set, the filament was grounded, this connection *must* be broken, otherwise the "B" battery would be shorted. Any type of tuner may be employed in the antenna circuit, but an untuned primary coupler is recommended. This may consist of a secondary of 50 turns of No. 20 S. C. C. wire wound on a three-inch tube. The primary consists of 10 turns of No. 18 or 20 S. C. C. wire wound directly over the center of the secondary and separated from it by two or three layers of cardboard. A variable condenser of .0005 mfd. capacity is shunted across the secondary for tuning. It will be noticed that the grid return of the radio frequency tube is connected directly to the negative filament, and that no potentiometer is employed. If the radio frequency tube tends to oscillate, this condition may be corrected by using fewer turns of wire on the primary of the variocoupler in the three-circuit set. As these turns are controlled by a switch, this is a very simple matter. There will be no danger that the tuning of the secondary will affect the tuning of the radio frequency amplifier as the coupling may be loosened to such a degree that this will be impossible. With the addition of this one stage of radio frequency amplification it will be found that regeneration is retained in the detector circuit, distance reception is increased and weak signals are greatly strengthened.

For those who wish a receiver incorporating one stage of efficient radio frequency amplification the circuit shown in Fig. 4 is recommended. This receiver bears a close resemblance to the circuit just described, but a tickler coil is employed for regeneration instead of a plate variometer. The tickler will not be found more efficient as far as actual results are concerned, but it will prove much simpler in adjustment. When using a plate variometer for regeneration it will be found that maximum results at about 250 meters will be had with the variometer set at minimum inductance and for 550 meters it will be set at maximum. Thus a rotation of 180 degrees must be made for maximum results to cover the broadcast band of wave lengths. When a tickler is employed it will be found that for the lowest to the highest broadcast wave length a variation of only about 10 degrees on the dial will be required. It will then be seen that once set for maximum regeneration on the lower wave, it is in a very sensitive position for the whole band and need only be touched to strengthen a very weak station.

This circuit also dispenses with the potentiometer, the absence of oscillation being due to the manner of winding the primary of the tuned radio frequency transformer. This instrument is a standard variocoupler of the 180-degree type. The primary winding should be removed and a new winding consisting of 42 turns of No. 20 S. C. C. wire wound on. This number of turns applies to a form of 3½ inches in diameter. If larger or smaller than this, less or more turns will be needed, respectively. This new winding will be the secondary of the coupler. The primary, consisting of 10 turns of No. 18 S. C. C. wire, should be wound directly over the secondary and separated from it by at least three-eighths of an inch. This may best be done by placing a layer of cardboard over the secondary and fastening eight pieces of hardwood, three-eighths of an inch high, at equal distances around the circumference (see Fig. 5.). These pieces of wood may be fastened in place by means of collodion. The wire is now wound on the edges of the wood strips and may be held in place by means of a light coat of collodion. If desired, any standard untuned primary coupler may be employed, but it will then be necessary to experiment with the number of turns needed on the primary to keep the R. F. tube from oscillating. This should be tried with the receiver set at a low wave length. The tuner, consisting of primary and secondary, may be wound the same as described for the circuit shown in Fig. 3. Condensers of .0005 mfd. capacity are employed to tune the secondaries of both couplers. For distance reception this receiver will prove superior to most two-tube sets on the market. If a loud speaker is to be operated one stage of audio frequency will be found sufficient for many stations.

Two stages of audio will give loud speaker volume on practically any signal that will actuate the detector. This receiver will not cause interference with other nearby sets as the radio frequency amplifier will not oscillate, and consequently will not radiate in the antenna system. Even though regeneration is carried too far and the detector tube oscillates, it will not cause any more interference than any laboratory oscillator.

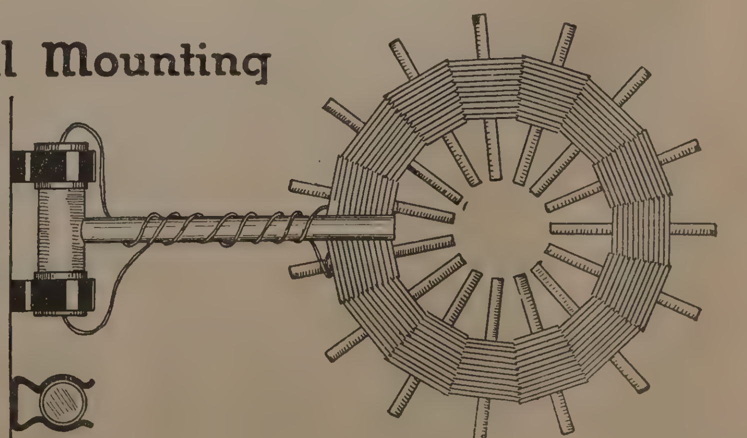
Inductance Coil Mounting

THIS spider-web coil is easy to make and simple to operate. The base is made from a 30-ampere fuse case, which, when snapped into the fuse clip, turns easily for coupling adjustment.

The stem is made from a meat skewer, and the coil is wound around match sticks which have been inserted in a circle of holes to give a round form before winding coils of different sizes can be wound for the primary, secondary and tickler. Very good results have been obtained with coils of this type on both tube and crystal sets.

Contributed by WALTER MARKOWSKI.

A very simple spider-web coil mounting is easily made with a 30-ampere fuse and its receptacle. The experimenter may mount two of these together and vary the coupling by swinging the coils sidewise. Different sized coils may be plugged into the fuse base.



Experimental Short-Wave Receivers

By A. L. Groves, 3BID

NOW that several bands of wave lengths have been officially assigned to the amateur for experimental purposes in addition to the 150-200 meter band, many are at a loss as to how they are to maintain efficiency over such a wide range of frequencies with the same set.

At present we may as well discount the 2 to 4 meter band except on sets especially designed to handle such high frequencies, but for the 20 to 22, 40 to 43, 75 to 80 and 150 to 200 meter bands, it is quite practical to use one set to cover anyone of these bands and maintain a fair degree of efficiency on any or all of them.

It is not the purpose of this article to state what is the *best* means of accomplishing this purpose—for short wave work is far too young for anyone to make any claims in this direction at the present time, but rather to describe some arrangements that have given good results for this class of work and which show prospects of development.

First of all let me warn those who are inexperienced in short wave work, not to let the natural efficiency of these high frequencies mislead you into believing you have a first-class receiver just because you happen to get pretty good results. Almost any half efficient set will give results at 75 or 80 meters superior to those which a well made set will give at 200 meters, provided it will tune that low, so watch your step and have everything as near right as possible if you desire to get the best possible efficiency.

Coils wound single layer fashion are apparently far superior to those wound in any other method for reception below 100 meters. Large enameled wire seems excellent and probably more desirable than any other.

Due to several causes three-circuit receivers (tuned primary, secondary, and plate) seem more effective than other arrangements where attempts are made to simplify tuning by doing away with some of the controls. Also in addition to these three main controls a variable feed-back between the plate and secondary coil is desirable as well as a variable coupling between the primary and secondary.

It is extremely important that small capacity variable condensers of good make be used in such sets. A five-plate condenser of standard size is recommended to be used across the grid coil and one of not more than seven plates across the plate coil. The one in the primary circuit had best be arranged for either series or parallel connection and may be of almost any size between 13 and 23 plates.

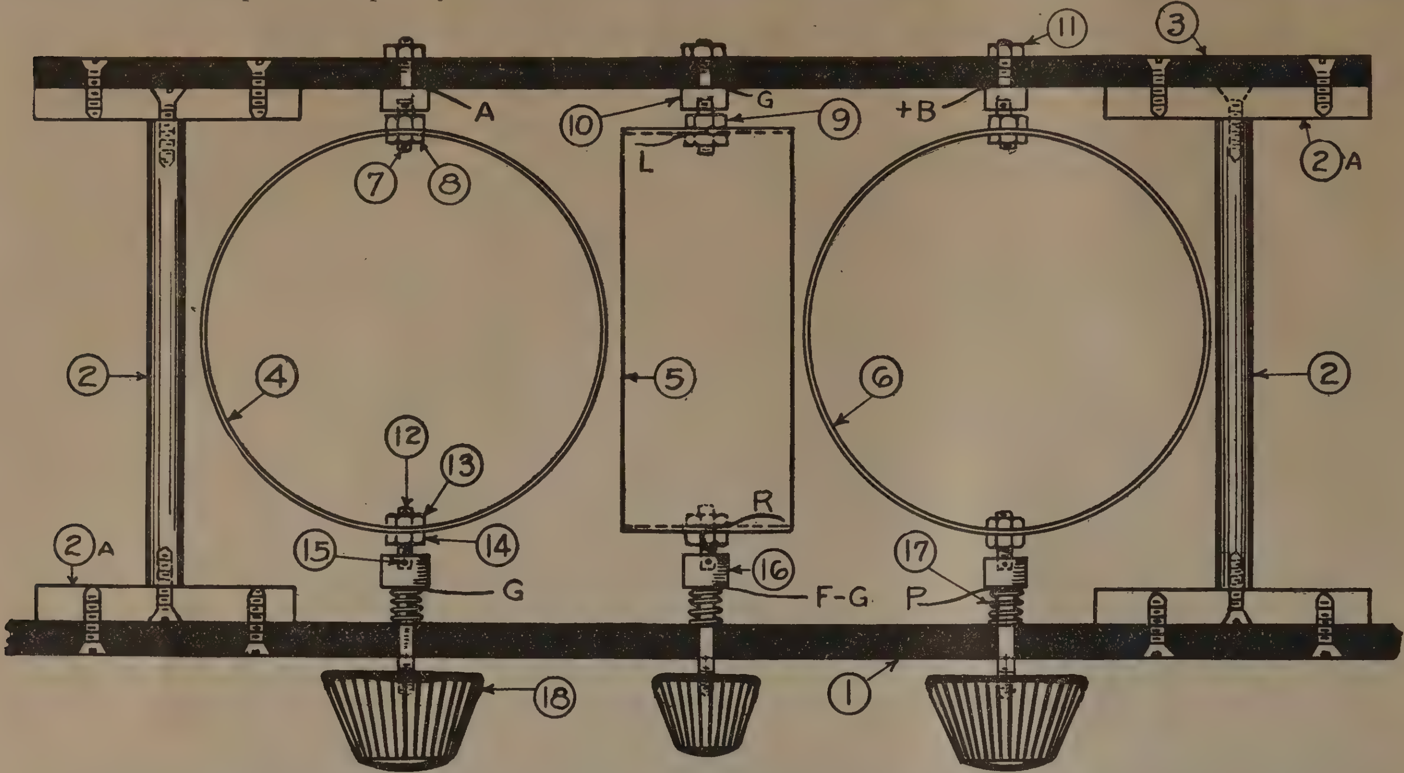
As the first important demand is for an outfit that will tune down to the short waves, a very good set for this purpose can be constructed in the well-known "honeycomb" method, and making several special single layered coils for work on the various bands of waves as desired. The coils should be wound on forms three inches outside diameter, each one equipped with an individual plug for inserting in the honeycomb mounting. The largest of these coils should be composed of approximately 22 turns. Other coils are made with about 18, 12, 10, 8 and 6 turns. Connect the instruments up in the regular honeycomb three-circuit system, not neglecting the small variables, for large variables in short-wave work are practically useless. With the condensers recommended and a 22-turn coil in the secondary and a 15- or 18-turn coil in the plate circuit and one of about 8 or 10 turns on the primary circuit, according to the size of your aerial, all wave lengths well over 100 meters may be tuned in while the minimum wave to which the set will respond will be approximately 80 meters.

As a rule with most sets it will be advisable to use the 18-turn coil in the secondary circuit and the 12- or 15-turn coil in the plate circuit for the 75 to 80 meter band of waves. The coil used in the primary in this and all other cases will depend upon the size of the aerial, of the primary condenser and upon whether the series or parallel connection of the primary condenser is used at the time. Such an arrangement will tune up nearly to 100 meters and go down to approximately 60 meters.

Placing the 15-turn coil in the secondary and the 10-turn coil in the plate circuit will allow the set to tune well below 50 meters. Other coils may be wound with different numbers of turns for various other wave lengths higher or lower. A 48-turn coil in the secondary and a 22- or 24-turn coil in the plate will cover the old 150-225 meter range nicely. On waves below 50 meters the effect of different length leads in the set during construction and different tube characteristics, etc., make it impossible to give the exact number of turns to be used for any wave length, but the experimenter will have little trouble with this part if he keeps in mind that one turn means a considerable frequency variation at wave lengths below 40 or 50 meters.

While such a set will work very efficiently and can be constructed quickly and cheaply it is recommended that for somewhat better results a special arrangement for mounting the coils be made, as the honeycomb coil mountings, while effective for the longer waves for which they were designed have several undesirable features that make them not so well suited to the high frequencies encountered below 100 meters.

The special mounting may be arranged according to one's own ideas in all details, the main consideration being a mounting that will allow for quick changes of coils and the bringing out of the opposing leads of the coil windings at opposite ends or sides of the cylinder. Good contacts of the bearings are also important. One suggested form of mount-



Amateur transmission and reception on wave lengths less than 100 meters have brought forward many new designs in receiving apparatus. This short wave tuning unit comprises primary, secondary, and tickler coils. By pulling the knobs out the inductances may be removed and different size coils substituted. Thus the entire amateur wave length bands may be covered.

ing that has proved quite satisfactory, and well adapted for mounting the coils behind the panel (no cabinet should ever be used in a short-wave set) is shown in Fig. 1. In this sketch (1) represents the panel which should be of bakelite; (2) is a 1/4 inch square brass rod 3 1/2 inches long drilled and tapped at each end with 6/32-inch thread; (2A) are 1/4 inch cross pieces 2 inches long, drilled transversely at about 1/4 inch from each end to pass a 6/32 inch machine screw, the center hole being countersunk. If desired the two side holes may be drilled and tapped for 6/32-inch thread, thus doing away with eight nuts in assembling. (3) is a bakelite strip about 1/4 × 1 inch × 10 inches long, used to support the rear bearings. (4) represents the primary coil, (5) the secondary coil and (6) the plate or tickler coil. The mounting hole for the secondary is drilled in the exact center of the bakelite strip and those for the primary and tickler not less than 1 3/4 inches or more than 2 1/4 inches to each side of the center.

To make sure of true running bearings, after the exact location of the mounting on the panel is decided upon, this strip is

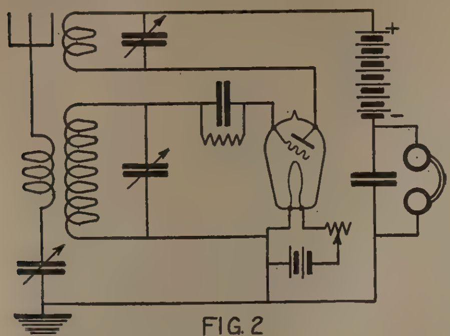


FIG. 2

The circuit used in the experimental short wave receiver. Note that antenna, grid, and plate-circuits are each tuned by a variable condenser.

used as a template in locating the corresponding bearing holes in the panel.

The bearings may be made as follows: (7) represents a No. 6 brass rod 1/2 inch long threaded 6/32 inch for about one-half of its length. (8) and (9) are 6/32-inch nuts used to fasten the rod to the bakelite cylinder. (10) is a 3/8-inch brass rod about 3/4-inch long turned down to receive a 6/32 or 8/32-inch thread for about 1/2 inch. The remaining shoulder is then drilled in the end for about 1/8 inch to receive the plain end of the rod (7). Special thought must be given to the contacting surfaces between the two parts to insure good electrical contact. The left-hand end of the winding is made fast under nut (8) as shown at (L), coil (5), or may be soldered thereto (especially after experiments have shown that the correct number of turns have been wound on the cylinder). The corresponding terminal in wiring the instruments is taken from under the shoulder of part 10 as shown at (A), the part 10 being held firmly in place on the strip by the nut (11).

The front bearings consist of a No. 6 or No. 8 brass rod about 3/4 inch long threaded about one-half its length, as at (12). A small pin is then inserted near the end of the unthreaded portion as shown at (15) and left projecting about 1/8 inch. (13) and (14) are nuts for holding this part firmly to the cylinder. (16) is a 3/8-inch or 1/2-inch brass rod about 1 1/4 inches long turned down to No. 8 size for about 1 inch of its length. This piece is then threaded for a short distance at the small end to receive the knob bushing while the end of the large shoulder is drilled to allow the plain part of rod (12) to slip in, after a slot has been made to allow the pin (15) to pass. Care should be taken to arrange the parts so that good electrical contact is maintained at this end and the rear bearing by pressure of the coil spring (17). The pin (15) fitting in the slot made in part (16) allows the entire coil to be rotated by means of the knot (18). Contact for the right-hand end of coil winding is made under the nut (13) as shown at (R) coil (5), and the corresponding terminal is taken off preferably between the coil spring and shoulder of part (16) as shown at (G). The coils may be easily inserted by pulling out on the knob thus compressing the coil spring enough to allow the coil to be removed or inserted. Separate parts (7) and (12) should be made for each coil. As it is not necessary to rotate the secondary or middle coil, only a small knob need be used on this mounting for the purpose of compressing the spring in changing coils.

The letters show the terminals to be connected to the various instruments. In connecting the variable condensers in shunt to the secondary and plate coil care must be taken that the stationary plates shall be connected to the grid terminal of the secondary coil and to the plate terminal of the plate coil. The negative filament lead from the secondary coil should also be connected to the ground.

The complete wiring diagram is shown in Fig. 2 to which should be added one stage of audio amplification for best results of DX stations.

The coils or inductances for this set are wound on bakelite cylinders three inches outside diameter and preferably of very thin walls and of correct width to receive the number of turns desired plus the space for the bearings.

It is important for short-wave work to place the condensers well apart, at least five inches between centers is recommended, and to use good condensers. The wiring and placing of the instruments should be so done as to admit of the least possible amount of wire being used. Medium "hard" tubes such as the WD-11 or WD-12 are recommended for the very short waves at least, where they seem to be well suited due to their low internal capacity, non-critical adjustments and free oscillating. The maximum and minimum wave-length range of the set will depend upon the number of turns used. Approximately the same number of turns may be wound to start with as recommended previously. Such a set will, if carefully made, give a good account of itself on all wave lengths in practical use below 200 meters.

Super-Regenerative Set

Contrary to general belief a form of super-regeneration can be used with splendid results and many advantages at times in connection with the short-wave sets previously described, especially on the waves between about 50 and 100 meters. The circuit for such a super-regenerative set is shown in Fig. 3. Great care must be made in constructing and adjusting the oscillator circuit for this class of work and it is upon these adjustments that the success or failure of the set hinges almost entirely. The regenerative part of the set should be constructed along the lines previously mentioned and the same care taken in the construction of this part as if the set was to be used as regenerative only. The variation frequency must be adjusted in such a manner that it is barely audible, and after experience is gained, best results may be obtained with the variation frequency entirely inaudible.

For some reason the WD-12 or WD-11 tube operating at 45 volts B battery seems to be more effective in this circuit than the more powerful storage battery tubes. The cause of this is not clear unless the variation-frequency-energy handled is so small, as to allow the tube to perform its other duties without becoming overloaded, thereby making a more powerful tube unnecessary and undesirable because of the greater natural efficiency of the smaller tube on the short waves.

Properly adjusted, this form of super-regeneration will not give rise to howling, squealing, and will not operate with the familiar roaring sounds to which super-regeneration is subject on the longer waves, and there is no bothersome hum in the receivers, for at the most this hum must be adjusted so it actually has to be listened-for to be heard even when no signals are coming in. Selectivity is enormously greater with this form of super-regeneration than on any other type suited to the longer waves, and while no earsplitting signals result the average signal should be found to double its strength over that received with plain regeneration and the distance over which the set will operate effectively in the day time should be increased something like 40 per cent over that of a good regenerative receiver. Adjustments and results will, of course, vary considerably in each individual case and no exact formulas can be given for

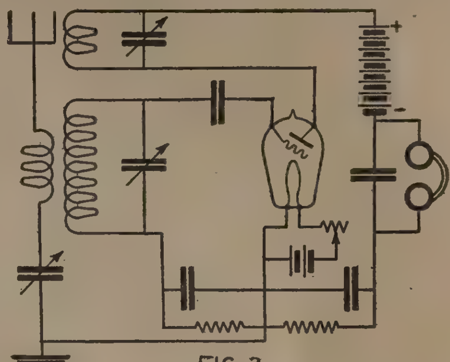


FIG. 3

A super-regenerative circuit for short waves employing the Flewelling principle. Experiments with this circuit show it to be far superior for short wave reception to the standard circuit.

the values of the oscillator inductances or their shunt capacities, but once working right the results will be steady with a decided radio-frequency amplification power. Approximate results may be first obtained by using D1-1250 turn coil in the grid oscillator shunted by a .001 mfd. condenser and D1-750 coil in the plate oscillator shunted by a .0005 mfd. condenser. The coils are placed in inductive relation to each other and adjusted until oscillations are noted by the faint high pitched sound in the receivers if the frequency is audible or a dull thud if it is inaudible. The coupling should not be any closer than absolutely necessary to maintain oscillations. Excellent results can be obtained if a little time is taken in getting the variation frequency correct. Do not be discouraged at the first attempt, if results are not perfect, and do not try to increase distance and signals by increasing the strength of the variation frequency, for although comparatively louder nearby signals can be obtained in this manner, the DX cannot force its way through and trouble will be experienced by the tube choking up, and signals chopping up in all unreasonable manners. More than 45 volts should never be used on the plate of any tube for this purpose. Always remember you have to decrease the strength of nearby signals as received on the super-regenerator to get results from the distant stations and general satisfactory results. It is no trouble to make any super-regenerator tear things up on comparatively short distances in the signal-strength line, but it is quite another problem to reduce this signal-strength and get smooth acting satisfaction from the distant stations. This is one great trouble of the past with super-regeneration and it

(*Continued on page 137*)

How to Make a Portable One-Tube Reflex Receiver

By Tud Garver

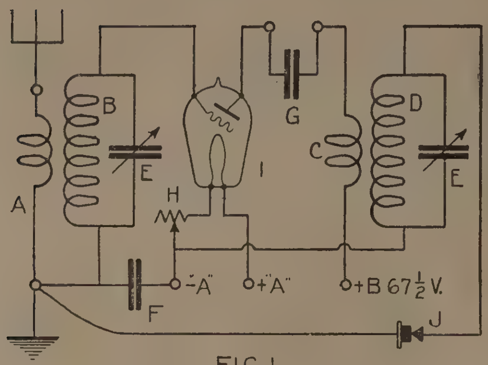


FIG. 1

FIG. 2

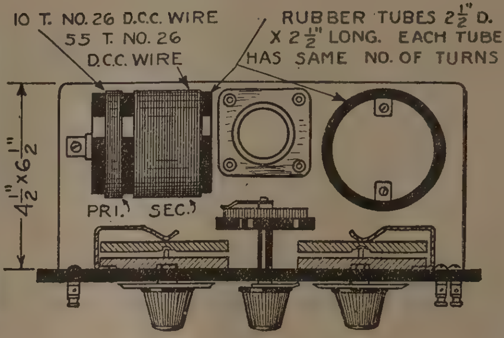


FIG. 3

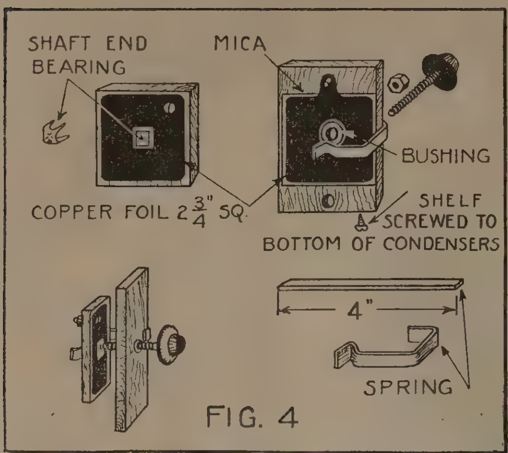


FIG. 4

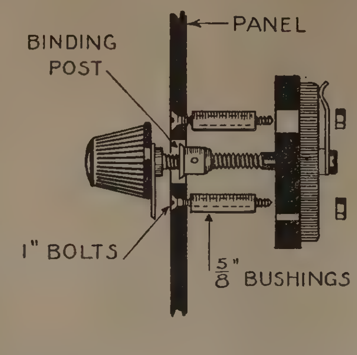


FIG. 5

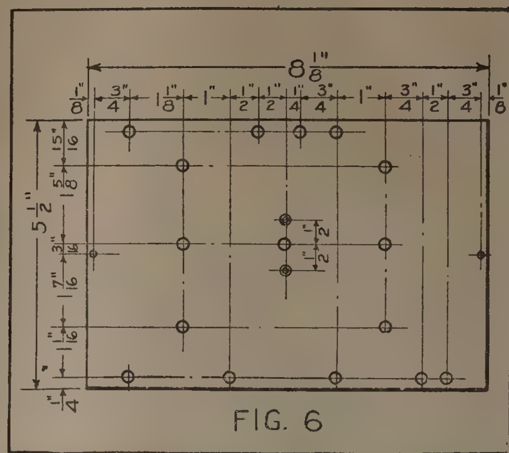


FIG. 6

Constructional details of a compact single tube portable reflex receiver that gives good results on a loop-aerial. Fig. 1 shows the diagram of connections. It employs a tuned plate circuit and the output of the crystal detector is directly connected to the input of the tube without the use of a transformer. Fig. 2 shows the rear view of the instrument. Fig. 3 is a plan view showing the location of the coils and the compact mica dielectric variable condensers, the details of which are shown in Fig. 4. Fig. 5 shows the method of spacing the filament rheostat to make room for the condensers. Fig. 6 shows the panel drilling. Figs. 7 and 8 show the compactness of the complete receiver installed in a medical cabinet.

FIG. 7

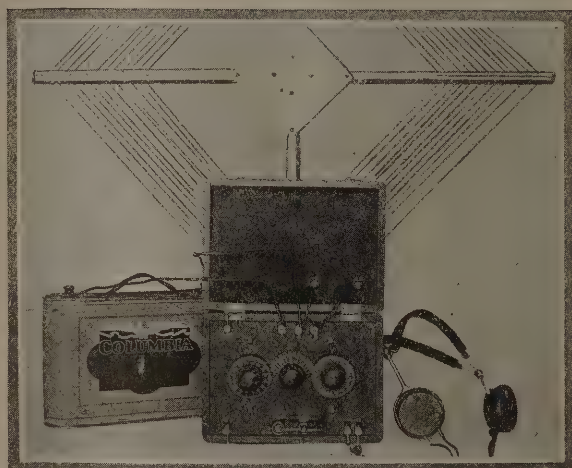


FIG. 8

HERE is a simple receiver free from complicated parts that is easy to build with a minimum of expense. It is mounted in a medical battery cabinet.

The parts needed are comparatively few and in the diagram each part bears a designating letter.

The electrical wiring diagram, Fig. 1, shows how to connect up the instruments exactly as they go in the set. With the exception of the grid lead of coil (B), which is soldered to the variable condenser lead, all connections are made to binding posts.

The photograph, Fig. 2, shows the arrangement of the instruments and the simplicity of wiring with direct, short leads. Note position of condenser (F) over coil (B); condenser (G) below sub-base and coil-supporting bracket (L). The crystal detector terminals are also below the sub-base. Connection to the movable condenser plates is made with flexible wire.

Fig. 3 shows the correct positions of the units as mounted on the panel and sub-base together with the mechanical details of coil construction and the proper connection of the leads. Coupling between the two sets of coils is eliminated by mounting them at right angles.

Owing to the small space available variable mica condensers are used. These are preferably one of the many commercial types or you may build them according to the drawings, Fig. 4.

$50.00 in Prizes

This is a monthly prize contest for radio experimenters. There are three monthly prizes as follows:

First prize......$25.00 in gold
Second prize.....$15.00 in gold
Third prize......$10.00 in gold

In order to be eligible for a prize the manuscript must deal ONLY with the experimental phase of radio, somewhat along the following lines: Radio *experimental* wrinkles. Short cuts for the *experimenter*. Simple devices to help radio *experimenters* in their work are wanted particularly.

This prize contest is open to all. All prizes are paid upon publication. If two contestants submit the same idea, both will receive the same prize. Address Editor, *Radio Experiments Contest*, c/o this publication. Contest closes on the 15th of each month of issue.

A minimum of panel space requires the rheostat to be set back of the variable condensers. This is done by using fibre bushings and a shaft extension as shown at Fig. 5.

Panel drilling plan is shown at Fig. 6. This plan should be followed very closely in order to build the set in such a compact space.

Fig. 7 shows the front view of the finished receiver.

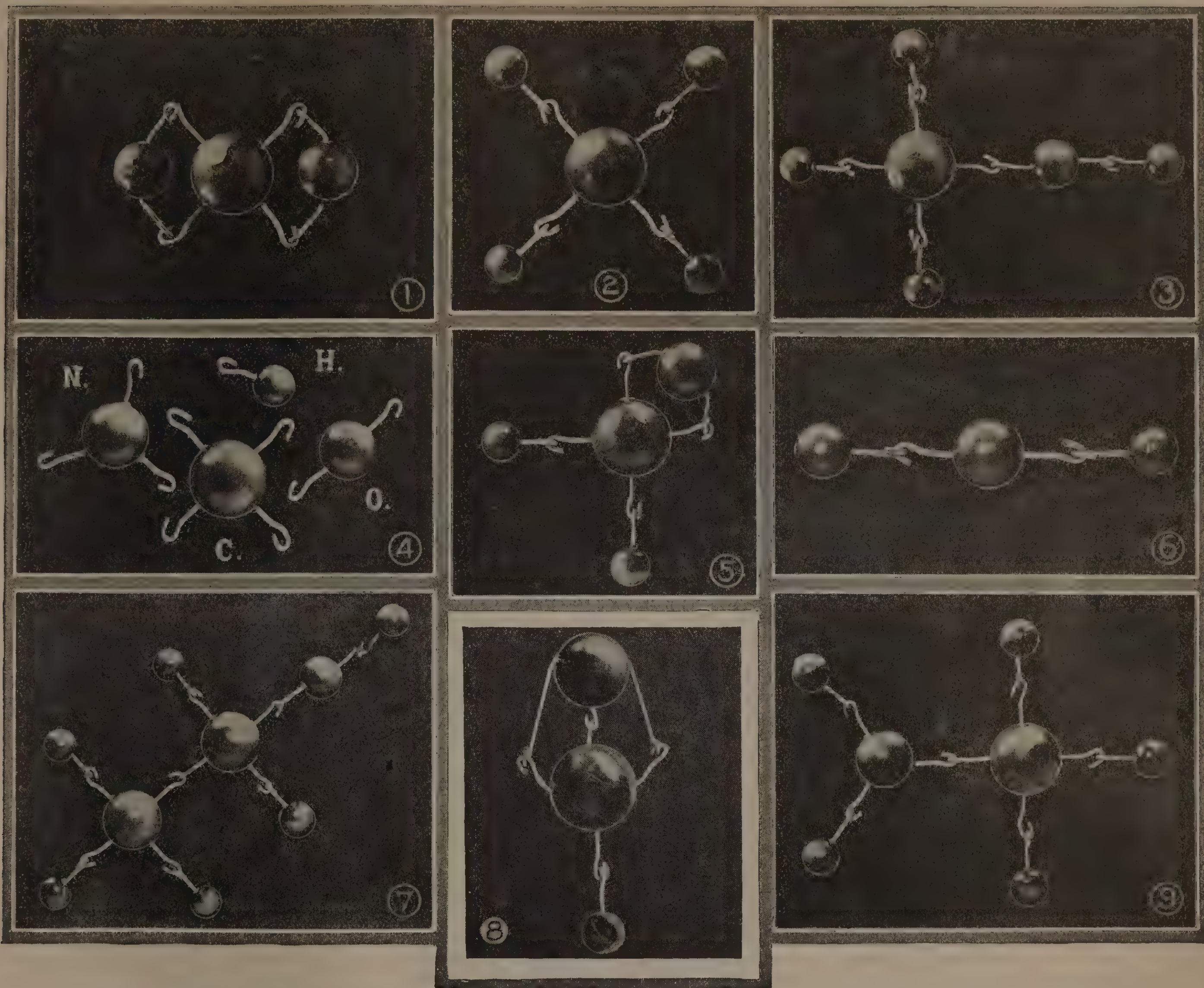
This receiver has shown its ability to pick up signals with fine volume on a tapped loop shunted with a .0005 mfd. variable condenser.

The neatness and portability of the set are well illustrated in the photograph, Fig. 8. Ample space is provided in the lid of the medical cabinet for "B" batteries. These are held in position by metal strips and the terminals brought out through a fibre panel. Complete with batteries the receiver weighs less than 20 pounds.

EXPERIMENTAL CHEMISTRY

The Dance of the Carbon Atom

By Dr. E. Bade



1. Carbon dioxide. 2. Methane, or marsh gas. 3. Wood or methyl alcohol. These three are made up of tetrad carbon and monad hydrogen atoms, and Fig. 4 shows the separate atoms, along with a triad nitrogen atom. Fig. 5 shows the bond of a tetrad satisfied by two monads and one dyad. This might be $COCl_2$ or COH_2, formaldehyde. Next comes water. Two monad hydrogen atoms and one dyad oxygen atom. Fig. 7 is grain alcohol. Fig. 8 shows the triad nitrogen taking up three bonds of the tetrad carbon, the other bond being saturated with hydrogen, giving us hydrocyanic acid. Fig. 9 shows another nitrogen compound, methylamine, the type of an enormously important series of compounds.

THE microscope shows, under the highest magnification of 3,000 diameters, living organisms which appear to have a diameter of one-tenth of a millimeter. In reality these organisms are only one-thirtieth thousand of a millimeter in diameter. But such a creature has a number of organs, each of which is composed of various organic compounds, which, in turn, split up into molecules, and it is these molecules which are composed of atoms. Therefore it is almost incomprehensible how tiny and minute such a molecule, to say nothing of the atom, must be.

The atoms when linked together form molecules, which are the smallest independently existing complex substances known. The atom has no independent existence. Each atom has its own peculiar characteristic. An atom of hydrogen (H) has what we may picture as one arm, called a bond, with which it may attach itself to another bond of the same kind of atom, or to a different kind of atom, forming a substance or molecule. Oxygen (O) has two bonds, nitrogen (N) in ammonia, three, and carbon (C) four bonds with which to unite to other atoms.

When each of the four free bonds of carbon are united with four atoms of hydrogen a molecule of marsh gas is formed. It is an interesting fact that marsh gas can be obtained by the direct union of carbon and hydrogen at a temperature of 1,200 degrees Centigrade, or by means of an electric discharge between two carbon poles in an atmosphere of hydrogen.

If an oxygen atom with its two bonds is substituted for one hydrogen atom of marsh gas an incomplete molecule is obtained, for since oxygen has two bonds, one bond is linked to one carbon bond, but one is still free. This free bond is taken up by the hydrogen atom just discarded and the cross-like structural formula is obtained which is of wood or methyl alcohol. When the hydrogen opposite the oxygen atom is removed and a carbon substituted, hydrogen being held by the three other bonds of the carbon atom, grain or ethyl alcohol is obtained.

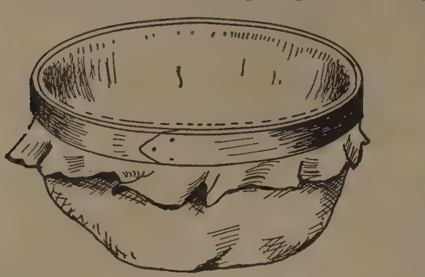
But the dance of the carbon atom is by no means finished. When the hydrogen atom attached to the oxygen of the wood alcohol is freed, as well as another adjacent hydrogen of the carbon, then the free end of the oxygen turns back on itself and locks to the free end of the carbon. This is formaldehyde, the well-known disinfectant and antiseptic. It can

(*Continued on page 139*)

Filtration and Crystallization

By J. Edmund Woods

IF you were given a sackful of various coins, what would be the first thing you would do with them? It goes without saying that whether you intended to save them, spend them or give them away, your first task would be to find out their value. This would necessitate sorting the coins into piles of equal denomination in order that you might count them. Such a simple operation may



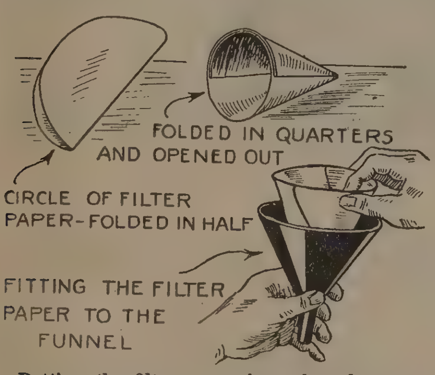
FILTER CLOTH SUPPORTED BY EMBROIDERY RINGS

Large volume filtration can be done through a filter cloth and embroidery rings secured in department stores are excellent for holding the cloth.

seem of little moment, yet separating or sorting things out is perhaps the most frequently recurring problem of our daily lives. The farmer separates the weeds from the vegetables. The dairyman separates the cream from the milk. The smelter separates the metal from the ore. Even the swindler separates the victim from his money.

Filtration is nothing but the separation of a solid material from a liquid, usually by straining through a screen that will permit the passage of the one while obstructing the passage of the other. It is precisely like fishing with a net, which is really a filtration of the fish from the water.

Filtration in the laboratory is generally done through paper, while industrial filters are usually of cloth. The word filter comes from the Latin "filtrum," meaning felt, as felt was first used for the purpose.



Putting the filter paper in a funnel. This is one way of doing it. Other ways will be described in a subsequent article. The funnel contains water, the little finger of the left hand closing the lower end of the stem.

Felt bags are still employed in filtering many pharmaceutical preparations. You can use cheesecloth for the following experiments, though it would be better to procure some regular filter paper if possible. This paper is obtainable at drug stores and is sometimes called bibulous paper, because it can absorb liquids.

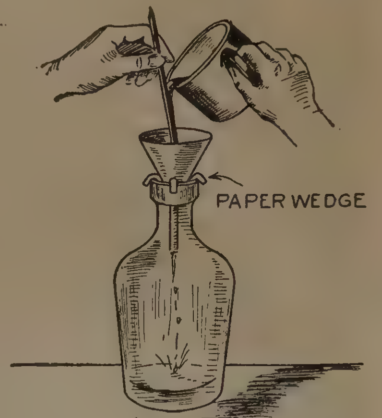
Take some fine sand, ashes or some clay broken up into small lumps and mix it with a quantity of common table salt. Add a little coal dust so as to make the mixture more complex, and then stir it all up in a vessel of water. Next prepare your filter. If this is to be of cheesecloth, take several layers of the material and attach them to a square or round wooden frame. Embroidery rings serve very well for this purpose. If you are able to get filter paper, a single layer will do, but it must be fitted to a funnel. Cut the sheet of paper into circular form with a diameter about one and one-half times that of the funnel. Fold the circle first in half and then in quarters so that it has the shape of a sector of a circle. This is to be opened out like a cone in the manner illustrated, and after putting a little water in the funnel the filter paper can be pushed down into it and made to fit the sides closely. A common enameled funnel is suitable for the present work though glass funnels of two to four inches diameter are preferable in laboratory filtrations. The funnel must be supported somehow and a good make-shift is to set the funnel in the neck of a clean bottle.

Pour the liquid through the filter with the assistance of a rod as the sketch indicates. A pencil will do for the rod. The chemist always uses a glass rod. The liquid passing through is called the filtrate, and it should be absolutely clear. If it is not, pour it through the filter paper again, as meanwhile the pores of the paper will have become clogged up to some extent with solid particles. If a cloth filter is being used, add an extra layer or two of cheesecloth. Naturally the more obstruction you place in the way of the liquid the slower it will filter through, but the separation must be absolutely complete. Not the least particle of solid matter should run through. The materials we have named should filter very well with the possible exception of clay.

Transfer the clear filtrate to a wide vessel, preferably a porcelain dish that will withstand heat, and leave it in a warm place so that the liquid can evaporate. When it has evaporated down to a small bulk, the dissolved salt will commence to crystallize out, and here you can tell how complete has been your separation. The crystals may be discolored by particles of coal which were small enough to pass through the filter. You can then dissolve the crystals and filter them again or else recrystallize, which is a common method of purification. The method is best shown in separating two substances which are both soluble.

Take a few ounces each of sugar and table salt, and after mixing, dissolve the mixture in as little water as possible. Expose the vessel containing the solution to a moderate heat so that the water will evaporate. After a time you will observe small crystals beginning to form on the surface of the liquid and around the sides. These should be practically pure salt, which is much less soluble than sugar and is therefore the first to crystallize. Collect the crystals on a little square of wire gauze with its sides bent up to form a basket. When about half the water has disappeared, take the basket with its collection of crystals and dip it two or three times in clean water. This will allow any adhering sugar solution to drain off. Then taste a few of the crystals. If the sweet taste of the sugar is discernible, the separation is incomplete and you must redissolve the mass in a little water and recrystallize. One or two repetitions should be enough to give you a pure salt. Note particularly the cubical shape of the salt crystals which is characteristic of this compound.

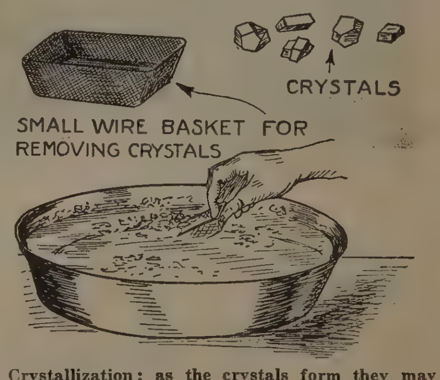
Isomorphous substances, or those that crystallize in the same form, cannot be separated in this way, and it is necessary to change one of them chemically. Procure about an ounce each of copper sulphate and ferrous sulphate. These are known to the trade as blue vitriol and green vitriol, respectively. Dissolve half of the blue vitriol and a little of the green vitriol in a small volume of water and let the solution evaporate. Crystals



POURING THE SOLUTION THROUGH THE FILTER

Filtering through a filter paper directly into a bottle. Paper wedges are placed between the neck of bottle and the funnel to allow air to escape.

made up of both compounds will appear, and the two cannot be separated. Now dissolve the remainder of the blue vitriol and a little fresh green vitriol separately. Add a drop of nitric acid to the latter and boil. This may cause a brown sediment to form, which will have to be filtered out before mixing the solution with the blue one. The effect of the nitric acid, which is what we call an oxidizing agent, is to change the ferrous sulphate to ferric sulphate. Ferric sulphate simply contains a larger proportion of the sulphate group than does ferrous sulphate, but the important point is that its crystals belong to a different system. Now evaporate your solution slowly and the copper sul-



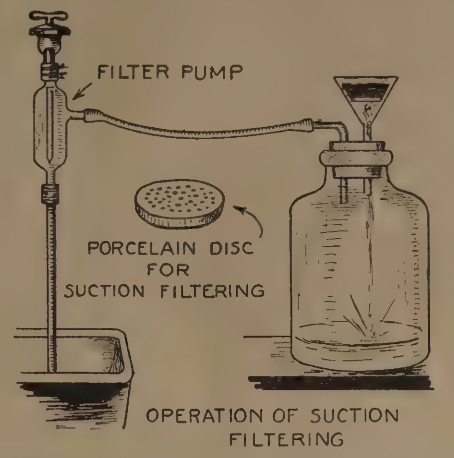
Crystallization; as the crystals form they may be removed by a little wire basket. If solution of table salt is used very beautiful basket-shaped aggregations of crystals are produced.

phate will crystallize out in nearly pure condition.

These operations will consume a good deal of time and meanwhile you can begin work on a method of rapid filtration called suction filtering. A few pieces of special apparatus are required, but you will find them handy for a great many laboratory uses. First of all there is the aspirator or suction pump, a simple form of which is illustrated here. The pump consists of a tapered glass tube sealed into a glass bulb which has a side outlet. When water passes rapidly through the tapered tube it carries with it some of the air in the bulb,

thus creating a partial vacuum in the bulb as well as in any closed vessel to which the side tube may be connected. The upper tube is attached to the water faucet by rubber tubing which is securely wired on so that a rush of water may not detach the instrument and break it. The side tube is joined to the filtering vessel as illustrated. An ordinary folded filter paper will not do for the rapid filtration that this arrangement is capable of, so we plug the funnel loosely with a small wad of absorbent cotton. This should be wet beforehand and the efficiency of the apparatus tested. On placing the palm of your hand firmly over the mouth of the funnel, you should feel a decided pull. Good water pressure and an extension to the outlet of the pump improve its operation, but the most important thing is to have the joints as tight as you can possibly make them. It may even be necessary to coat the cork of the filtering flask with sealing wax so as to avoid leakage.

Now prepare a turbid liquid, say, of coal dust and water and pour it into the funnel. At the same time turn on the water faucet so that the pump will begin to act. A very rapid flow of clear water through the cotton filter should occur.



Filtering by a vacuum; a simple filter pump draws air from the large bottle so that the liquid is forced by atmospheric pressure through the filter paper.

This device is one of the most effective time savers in the laboratory and you will find almost countless applications for it in your general work. It may be stated at this time that cotton is not the best material for this kind of a filter, and it is well to obtain some asbestos wool if you can. The wool comes in small fibers and has to be supported in the funnel by means of a perforated disk, usually of porcelain. The ordinary filter paper can be used with the disk. Some chemists prefer the Gooch crucible, which is a small porcelain cup having a perforated bottom. When lined with filter paper or asbestos wool it serves the same purpose as the disk and is attached to the funnel by means of wide rubber tubing. Any of the laboratory adjuncts we have described can be procured from the regular dealers in such supplies.

The next article will treat of other standard methods of separation and purification by which important commercial processes can be carried out in your own home.

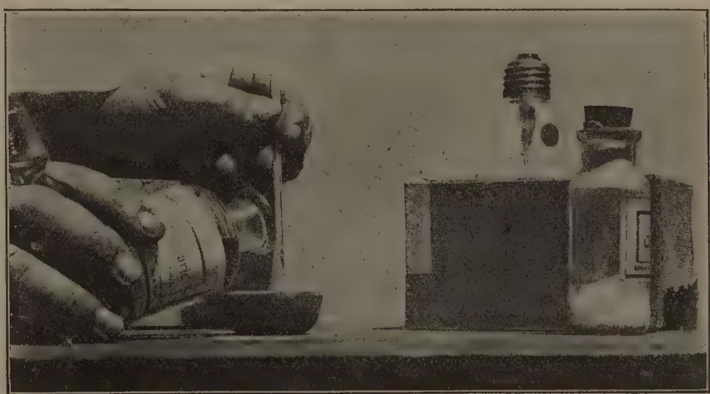
Chemistry in the Home Laboratory

By Dr. E. Bade

ONLY too often the home laboratory becomes a place of play where a number of chemicals are just mixed together to see what happens. It is seldom that anything does happen, but when it does, it is a serious matter. Accidents occur anywhere and any time, but it is really not necessary to work promiscuously with chemicals. Many interesting and instructive things can be accomplished in the simplest laboratory. The equipment need not be extensive but can be enlarged gradually as new chemicals and apparatus are required.

Our experiment shall be the frosting and etching of glass. This is not at all difficult if chemical methods are employed. Any type of glass may be etched, even the electric bulbs may be so prepared. One piece of apparatus is essential, and this is a lead dish. The chemicals required are powdered calcium fluoride, sulphuric acid and paraffin. A small cardboard box which can be tightly fitted is also to be provided.

If an entire piece of glass is to be frosted, then one side of the glass is coated with paraffin and placed in the box which is the chamber in which the fumes of hydrogen fluoride, which attack the glass, are generated. All those parts of the glass exposed will be etched, those parts covered with paraffin will remain unattacked. A design can also be worked on the glass.



Etching or frosting the glass bulb of an incandescent lamp with hydrofluoric acid; the mixture of sulphuric acid and calcium fluoride supplies the gaseous acid, and the glass will be permanently frosted.

The entire glass, both sides if it is flat, or inside and outside if it is a tumbler, are covered with paraffin. The paraffin is melted and brushed on the glass with a soft brush. Then the design is scratched in the wax after it is cold, care being taken to remove all wax from the design to be etched. The glass so exposed is acted on by the gaseous hydrofluoric acid which frosts the glass on these spots. If only part of a bulb, say the lower half, is to be frosted, then the cardboard box receives an opening through which the bulb is introduced. It must fit tightly, and the edges of the hole in the box must also be covered with paraffin to prevent the escape of the gas generated.

The gas is produced by mixing the harmless calcium fluoride powder, about one-sixth of an ounce, with sulphuric acid, using enough concentrated acid to make a thin paste. Stir the mixture thoroughly together with a wooden paraffined rod, taking great care not to inhale the very poisonous gas which escapes slowly. Be sure that the dish used for mixing is of lead; glass dishes will be etched and will use up acid. As soon as the mixing is complete place the dish in the cardboard box, place the glass in it, close the cover and seal, if necessary, with paper glued to the edges of the box to make it tight.

The entire box is now placed out of doors and covered with a wooden box to protect it from the dew. If an evaporation hood is at hand, it can be placed in it. The escaping gas should not enter a room. Leave the box out of doors until the second day, then remove it, take out the glass, rinse it with water, take the lead dish and thoroughly clean it by letting a stream of water play on it until the paste is removed.

Remove the paraffin from the glass by warming it and wiping it off. All parts will be etched which were exposed to the gas; those parts covered with this wax are protected from it and are unaffected.

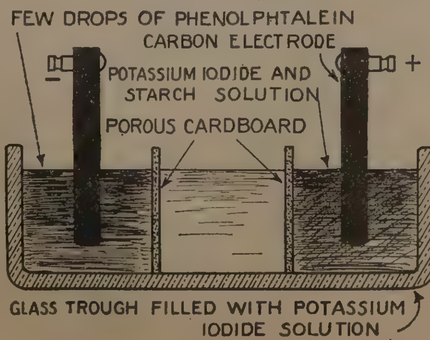
Chemical Tricolor

By Arthur A. Blumenfeld

FILL a long glass trough with a solution of potassium iodide and divide the trough into three compartments with two pieces of porous cardboard. In the first compartment put a few drops of phenolphthalein and in the third compartment put some starch solution.

Then put a carbon electrode in the first and third compartment and attach the negative of a battery of dry cells to the first electrode and the positive to the electrode in the third compartment. In a short time the compartments will be respectively red, white and blue.

What takes place is this—the current decomposes the potassium iodide and the alkali appears in the left hand division and affects the phenolphtalein. This gives the red. The central division determined by the porous paper, is unaffected. The right hand compartment has iodine set free by the current and this produces the characteristic and exceedingly sensitive starch reaction.



A very interesting experiment in electro-chemistry. A tank is filled with colorless solutions. On passing electric current through it, a blue, white and red coloration like a French flag is produced.

Electro-Chemistry Experiments

[Continued]

By Floyd L. Darrow

Electrolytes and Non-electrolytes. It is an interesting fact that most chemical compounds can be divided into electrolytes and non-electrolytes. An electrolyte is a compound which in solution dissociates into minute positively and negatively charged particles called *ions* and conducts the electric current. A non-electrolyte does not thus dissociate and does not conduct the current. To be sure, no chemist ever saw an ion, but few chemists doubt that these small particles exist. At least solutions behave as though they do.

To determine what substances are electrolytes and what ones are not will form a most interesting piece of experimental work for any home-laboratory worker. To do this best requires a small electrolysis apparatus having platinum electrodes. A simple form of such apparatus for the electrolysis of water is shown in an accompanying figure. Small platinum electrodes are fastened to heavily insulated copper wire. These are placed in a small jar containing water and a little sulfuric acid. Over these electrodes are inverted test tubes also containing acidulated water.

When this apparatus is connected to a half dozen bichromate cells or to the 110-volt direct current with one lamp in series, chemical action will at once be observed and gases will be seen to collect in the tops of the test tubes. If the direct current and lamp are used, the lamp will light, thus showing the passage of the current.

It will be interesting to test the gases given off. To do so lift one of the test tubes when quite full from over the platinum, and light it. It will burn if it is the hydrogen tube. Meanwhile the other is filling. Remove when full, invert and apply to its mouth a glowing splint; oxygen will cause a vigorous combustion of the splint. Now in the above experiment the sulfuric acid is the electrolyte, and the water is simply the dissociating medium. Rinse the apparatus out thoroughly and place in it pure water. No action will be observed. The incandescent lamp will not light, and no gases will collect.

If you have no platinum for electrodes, simply place in your jar pieces of copper connected to copper wire. Of course the copper will be acted upon chemically at one of the electrodes, but that will make no difference with the determination of whether or not a substance is an electrolyte. You can still observe any chemical action and note whether the lamp lights.

Now in turn place in your apparatus fairly strong solutions of any chemical compounds at your command and try to pass the current. Be sure each time to rinse out the apparatus thoroughly before putting in a fresh solution. No inverted test tubes need be used now.

Try the ordinary acids first. You will find that they are all good electrolytes. However, you will find that acetic, oxalic, and tartaric acids are very poor. The better an acid dissociates and conducts the electric current, the stronger acid it is. Try solutions of the ordinary bases—sodium, potassium calcium, and ammonium. Which are strong bases and which weak? Test solutions of the various salts.

Then test alcohol and solutions of sugar and glycerin. These last compounds belong to the class of organic compounds, which in general do not dissociate and do not conduct the current.

Electroplating. During the Great War I visited one of the largest copper refining plants in this country. There I saw, filling at least an acre of floor space, huge electrolytic refining baths, converting the relatively impure copper from the smelter into metal 99.98 per cent pure. The principle involved here is an application of the electric current identical with that of ordinary electroplating, which you may easily carry out.

From Author's *Boy's Own Book on Chemistry.*

Weighing with a horn scale. The weights are handled by pincers, as the hands must never touch them. The horn scale, owing to its lightness, is really quite sensitive and will answer for rough work.

Place in a battery jar 250 grams of copper sulfate, ordinary blue vitriol, and dissolve it in a liter of water. At one side of the jar suspend a fairly heavy square of copper and connect it to the positive pole of your battery or source of current. One or two cells of a storage battery or two or three gravity cells in series will be best for this kind of work. Opposite to the square of copper suspend an iron door key. Before doing so, however, clean it thoroughly. Polish it to remove corrosion. Wash it with soap or dip it in a solution of sodium hydroxide to free it from grease and rinse it with clean water.

Now pass the current. For a good, firm coat only a small current should be used, and it should be allowed to run for some time.

The Chemical Action Is This: The key, which you are plating, being connected to the negative side of the battery, is the cathode or negative pole of your electrolytic cell. The square of copper is the anode. As the current passes, the positively charged copper ions are drawn over to the cathode where they give up their charges and attach themselves, thus plating the key. At the same time the negatively charged sulfate ions are attracted to the anode where they discharge and then draw into solution more copper from the anode. If you will weigh the anode before and after the experiment, you will find that it has become lighter. In time the anode will have wasted away and it must be replaced.

Determination of Copper in Brass. An interesting analytical application of this process is found in the determination of the percentage of some metal in a given alloy. If you like, you may carry out this determination for yourself.

With tin shears cut out a small sample—about a gram—from a piece of brass. Weigh it carefully in hornpan scales, or better ones if you have them. Dissolve the brass in nitric acid and make up the solution to 500 c.c. Then carefully weigh a clean iron dish. (Small ones similar to an evaporating dish may be had.) Place in this dish 50 c.c. of the solution. That will contain one-tenth of the sample of the alloy which you dissolved. Suspend in this solution, but so that it will not touch the bottom of the dish, a copper wire spiral-shaped to increase the surface and connect it to the positive pole of a storage battery or to several gravity cells in series. Connect the dish itself to the negative pole of the battery. Allow the current to flow until the blue color of the solution has entirely disappeared. A good way to determine when all the copper has been deposited from the solution is to remove a few drops of it to a test tube and add a little ammonia water. If any copper remains in solution, a blue color will result.

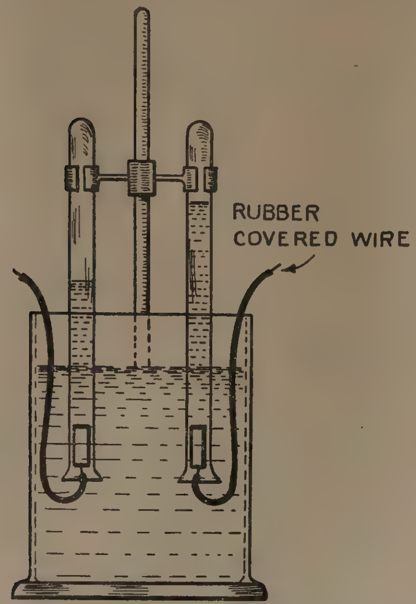
When all the copper has been deposited from the solution on the iron dish, break the circuit, remove the copper spiral, and pour out the solution. Rinse the deposited copper with clean water, then with alcohol (denatured will do) and dry it in an oven at a low temperature. If the oven is hot, both the copper and the iron will oxidize and the determination will be worthless.

Now weigh the dish. The increase in its weight will be the amount of copper in one-tenth of the sample taken. From this data, you may easily determine the percentage of copper in the brass.

Local Action and Polarization. Two of the chief defects of a number of the simple cells are local action and polarization, both chemical effects.

To learn the nature of local action, place a strip of ordinary sheet zinc in a tumbler of dilute sulfuric acid. At once you will notice a vigorous bubbling around the zinc and small black particles floating up to the surface of the acid. Commercial zinc always contains impurities, chiefly

carbon. When such zinc is placed in acid, we have exactly the conditions necessary for a myriad of tiny electric cells. Between each particle of impurity and an adjacent particle of zinc a miniature couple is formed, and a current is set up. This results in a waste both of acid and zinc.

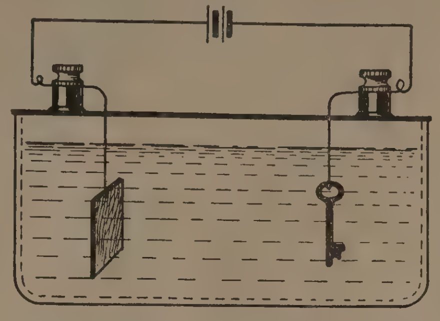


Electrolysis of water; the radio operator's spaghetti would be a convenient covering for the wires, if rubber insulated wire is not at hand.

Now, if you have at hand a little mercury, rub the zinc with a bit of zinc or galvanized iron as already described, and the mercury will spread over its surface. This process is called amalgamating the zinc, and it covers up these little particles of impurity so that the tiny cells can no longer form. Again place the zinc in the acid and you will find that this local action has disappeared. To prevent local action, either pure zinc must be used or the zinc must be amalgamated.

All cells which produce hydrogen tend to polarize. That is, a layer of discharged hydrogen bubbles collects on the positive plate and forms a non-conducting surface which stops the action of the cell. You have often noticed how a dry cell quickly "runs down" on closed circuit, but rapidly recovers on open circuit.

Place a simple acid cell on short circuit and notice the layer of hydrogen bubbles which forms over its surface. If you have a voltmeter, connect it across the terminals of the cell and parallel with it a variable resistance. With a resistance of



Electrical analysis of a key. This is a very pretty experiment, involving the deposition of copper from the key and weighing of the same. If the key is of true brass the difference will be zinc.

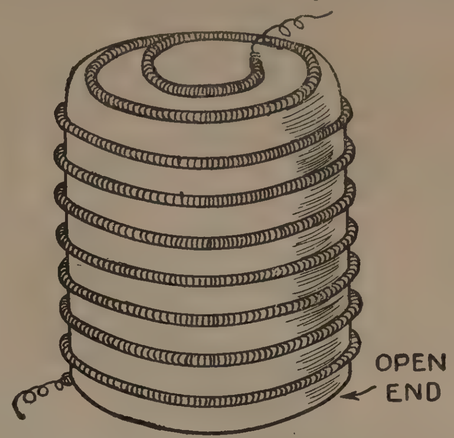
about 15 ohms note the reading of the voltmeter. Allow the current to flow for two minutes and again take the reading of the voltmeter. This time it will be found to be much less. Now reach into the cell with a stick of wood and wipe the bubbles of hydrogen off the copper plate. Immediately the voltage will rise to its original value, showing that the accumulated hydrogen gas stops to a large extent the action of the cell.

An Electric Furnace. Although the electric furnace is not a direct chemical application of the electric current, yet because it is so useful in the laboratory I am going to describe the construction of one. Of course before making it, you must understand that either D. C. or A. C. current of 110-volts pressure is required for its operation.

The most useful electric furnace is of the resistance type. It depends for its value upon the heat-producing properties of an alloy known as nichrome wire. Although for a time, on account of patents, it was impossible to buy this wire in the market, it is now available for anyone.

The materials for this furnace are fire clay, asbestos fibre, water-glass, a corrugated alundum core 2½ inches deep and 2 inches in diameter, and 42 feet of No. 20 nichrome wire. The first step in this process is to wind the wire as closely as possible on a spindle 3/32 of an inch in diameter. This is difficult to do by hand, and it is better to have it wound at a machine shop. Be sure to leave about a foot free on each end for connections. Stretch the coil slightly so that the turns will not touch and short circuit. Then wind it about the alundum core, fitting it into the grooves. You will have some difficulty, probably, in holding the coil in place until you can cover it with a layer of alundum cement. The cement powder is simply mixed with water and spread on to a depth of about a quarter of an inch. Place the core in a warm place and let the cement set.

The rest is simple. Obtain a box about 8 inches long, 6 inches wide and 5 inches deep. In an old basin mix into a doughy mass some of the fire clay, asbestos fibre and water-glass. Press a layer of it into



A simply constructed furnace for use in the laboratory. A coil of wire heated by the current produces the heat. It sometimes happens that one has to work in a laboratory without gas.

the bottom of the box and set the alundum core upon it, making the mouth of it just level with the top of the box. Now pack firmly about the core more of the mixture, until the box has been completely filled. Smooth off the top and insert in one end two binding posts, to which fasten the free ends of the nichrome wire. Now place the box in a warm place and let it remain until it has dried and hardened. This process may be hastened by connecting the furnace with the electric current. In the meantime you may make a cover for the furnace from the same materials as the furnace itself. In doing so leave a small hole in the center directly over the pit to serve as a vent.

When the furnace is dry, cover it with a thin layer of cement in order to smooth up the surface. When ready for use the current from a 110-volt source should give a heat of almost 1,000 degrees Centigrade.

This furnace will be found useful in making alloys, quicklime, the reduction of metallic oxides with carbon, and in the preparation of coke and illuminating gas and for many other purposes.

A Chemical Motor

By C. A. Oldroyd

A UNIQUE chemical motor, which will rotate slowly for a long period, can be constructed as follows:

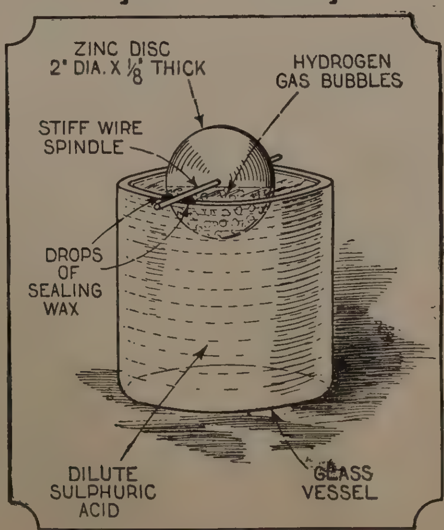
From a zinc plate, about one-eighth inch thick, a disc having a diameter of two inches is cut. Through the center of the disc a small hole is drilled; later, a steel wire is forced through the hole to act as a spindle or shaft.

By filing down the heavier side of the disc the rotor is perfectly balanced, so that the disc, if placed on a glass tumbler (as shown in the illustration), will remain stationary in any position.

To start the rotor, the tumbler is filled with a dilute sulphuric acid solution, and almost immediately the motor disc will begin to turn slowly.

The explanation is that hydrogen bubbles are formed on the zinc disc; these bubbles displace water, and cling to the zinc, thereby acting like little floats.

Owing to the uneven surface of the disc, bubbles will form more quickly on



one side than on the other (shown in the diagram by + and — signs), and the side which has the greater "lift" caused by the bubbles will be lifted up and rotation will begin.

Once started the motor will continue to run for a long period at a regular low speed; for the surface of the disc sub-

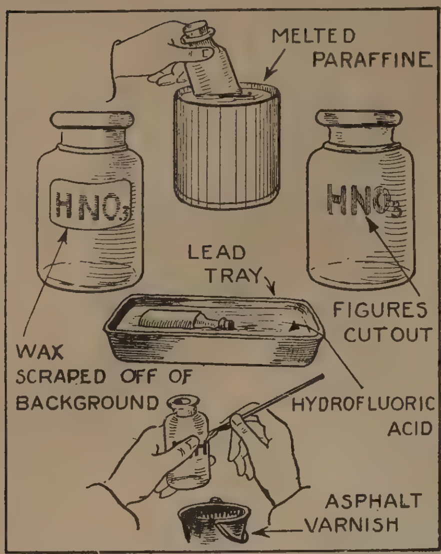
The accumulation of hydrogen irregularly on the surface of a zinc disc immersed in acid and dissolving slowly therein, throws it out of balance and it rotates, constituting a chemical motor.

merged has already bubbles adhering to it, while the new sections immersed by the rotation have to remain in the acid for a few moments before bubbles form.

In the meantime, the other (+) side, has the upper hand, and is lifted from the acid by the buoyancy of the hydrogen bubbles adhering to it.

Indelible Labels for Reagent Bottles

IT is often desirable to label vials and bottles in such a way as to prevent the destruction of the labels by the stronger reagents. An etched label filling this requirement may be made in the following manner:



Etching labels on bottles for the laboratory. This is a practical application of the experiment described in Dr. Bade's interesting article in this issue.

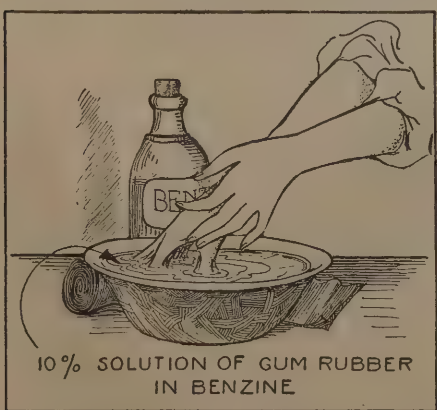
The bottle is first dipped into melted paraffin so that its entire outer surface is coated. When the wax has set, the letters may be drawn with a stylus or knife point. Two methods are shown, one giving raised figures on an etched background, the other etched figures.

The prepared bottles are then placed in a tank of hydrofluoric acid so that the parts from which the wax has been removed are covered by the acid. The acid container should be either of lead or coated on the inside with paraffin. Leave the bottles in the acid for several hours, or until they appear to be sufficiently etched. After washing thoroughly in hot water, the figures may be filled with a black asphalt varnish, applied to the etched portions with a small camel-hair pencil.

Contributed by PHILIPPE A. JUDD.

Substitute for Rubber Gloves

DIPPING the hands in a 10 or 12 per cent solution of raw rubber in benzine will act as a substitute for the use of rubber gloves and will prevent many bad burns when working with acids. The hands should be spread out for several minutes until the benzine has evaporated.



Coating the hands with rubber solution, intended as a substitute for rubber gloves to protect the skin. Yet a chemist should as a rule know how to take care of his hands without protection. Stains generally are unnecessary.

This kink is also useful in handling paper, as it prevents finger-prints and is superior to gloves in this instance in that it does not affect the sensitiveness of the finger-tips. To remove the coating wash the hands in benzine, or rub it off. It will roll up into crumbs and come off.

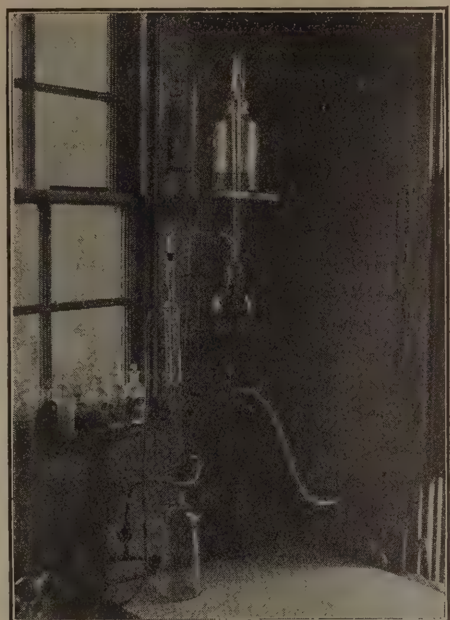
Contributed by PHILIPPE A. JUDD.

Continuous Water Still for the Laboratory

By RAYMOND B. WAILES

DISTILLED water is at times a necessity for laboratory work. Although some city water contains so little dissolved solids that the water is used for storage batteries, well, spring and other waters are so full of dissolved salts that distilled water is absolutely the only type of water to use in a battery.

A chemist, too, would not think of using a water from a well or even a city water to determine the quantity of iron or chlorides in a substance, for the solutions used would cause an appreciable error in the analysis. The sketch shows a water still which operates *continuously* and produces distilled water in fair amounts regularly. The whole is easily made by the average experimenter, the amount of glass blowing, or rather bending, being little; only seven bends in glass tubing are required.



A corner of the writer's laboratory, with a continuous water still set up to supply distilled water for analyses.

The still proper consists of a one liter (1000cc) Pyrex flask, round bottom. Flat-bottomed flasks should never be used for boiling. The reservoir containing the reserve water is shown as (R). It is a large bottle. The glass tube (D) connects the bottoms of the reservoir and the distilling flask. The glass tube (A) is the regulating tube and passes from the air head in reservoir (R) to the water level of the distilling flask (S). This tube should end about half way in the flask (S). The offtake (U) carries the steam from (S) to the condenser (C). Tap water should pass in the bottom of this condenser and out of the top.

As the water boils from the heat of the Bunsen burner burning with a small flame, the steam passes into (U) and is condensed and collected at (W). As the water boils away, the water in tubes (A) and (D) will change. That is, air will enter the bottom of tube (A), for the tip has been uncovered by the water which has boiled away, as the water level in (S) is now lower. This air will enter to the top of (R) and allow water to syphon through (D) into (S), filling up the water level in the still (S), and thus sealing the open bottom of the tube (A), which had become unsealed. This operation cuts off the air passing by suction, through (A), and stops the flow of water from (R) so that (S) will not overflow.

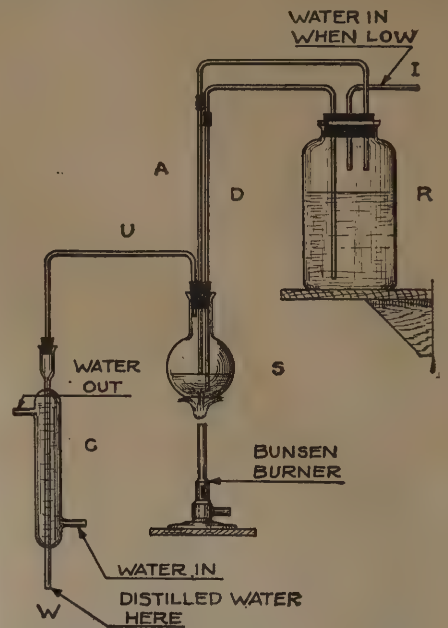


Diagram of the continuous still, showing its mode of operation.

The tubes (A), (D) and (U) should be all glass, except, perhaps, for two little rubber connections in (A) and (D). These should be very short and tight. The ends of the glass tubing in each should come together, avoiding exposure of the water to the rubber.

An asbestos covered wire gauze or a plain wire gauze should be used beneath (S), allowing (S) to rest upon it. This will prevent the cracking of (S) by sudden temperature changes of the Bunsen burner.

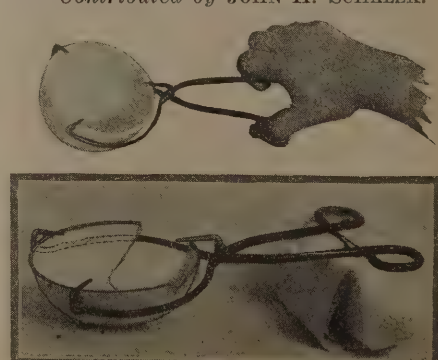
Of course, when the reservoir (R) runs low in water content the burner should be turned off and water added through the inlet (I) of (R). This inlet should be closed when the still is operating.

Chemical Tongs

TONGS for the use of chemists have recently been evolved, differing materially from the old familiar ones.

The implement we illustrate has arced jaws which will fit a large variety of sizes of evaporating dishes. Not only do the jaws hold the dish below, but three projections, two from the ends of the jaws and one from the fulcrum, reach over the edge of the vessel, increasing the security of the grip very greatly.

Contributed by JOHN H. SCHALEK.

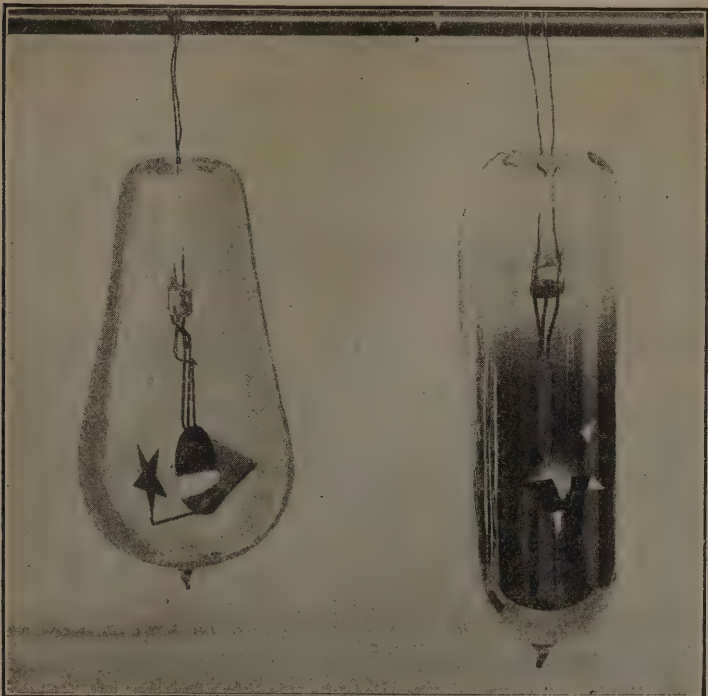


Improved chemical tongs. In the lower view the dish is broken away to show how the tongs grip it. Note rubber band.

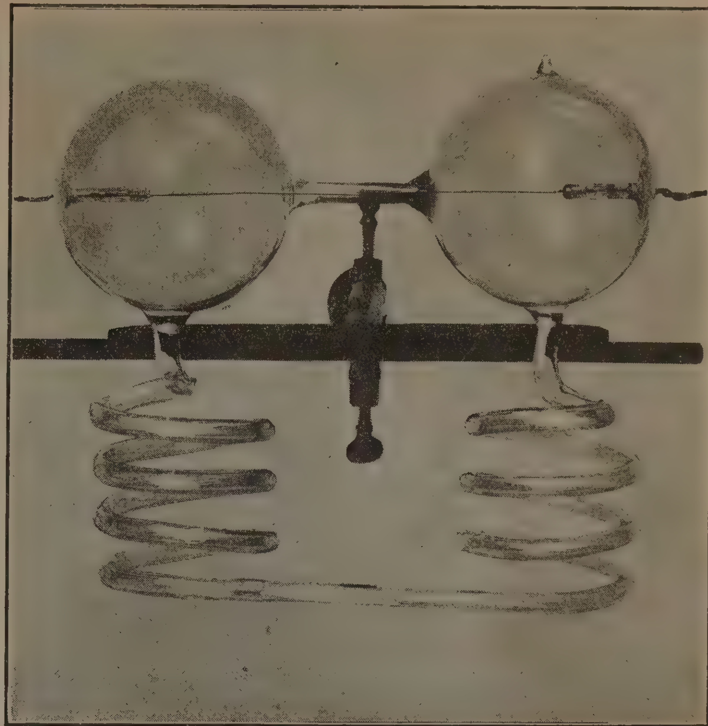
The Vacuum—There's Something In It

Abstract of Lecture By Dr. W. R. Whitney
Director, Research Laboratory, General Electric Company

EVERYBODY pretends to know that "nature abhors a vacuum." But he who started that tale merely meant that a good vacuum was hard to produce. As probably no one has ever made a vacuum with less gas-molecules in a cubic inch than there are people in the world, we can maintain that perfection in vacua is still precluded by nature.



The evaporated gold from a gold-plated tungsten filament, in the experiment illustrated above, casts a marked shadow on the walls of the vacuum tube when a design is interposed, showing that the molecules of the evaporated substance travel in straight lines in high vacua.



That electrical discharges do not always follow the shortest path can be demonstrated by the tube shown above. Hittorf using a high vacuum tube with 1 mm. between electrodes and with the helical tube 375 cm. long, found that at certain potentials the discharge showed decided preference for the longer path.

The latest arrival in the family of the chemical elements (hafnium) was discovered by trying it in vacua as an X-ray target. Our list of possible chemical elements was rounded off by Moseley's study of the X-ray spectra just in time to meet the wonderful discoveries of J. J. Thomson and Aston, all made in vacua. The latter showed that most of the elements, supposedly simple, are still mixtures of two or more similar elements (isotopes), while Professor Thomson's experiments disclosed by the positive ray method a whole series of new atomic compounds.

While the vacuum was not essential to the work of Millikan in isolation of the electron, yet the earlier work by Thomson and others, and much of the recent work on this ultimate constituent of matter, has been necessarily carried out in vacuum. Today there seems to be no end to the studies which can be based on the fact that an atom or molecule of material may be separated electrically into a positively charged ion (carrying most of the mass) and a negatively charged electron (carrying most of the current).

Electricity

I may not be sacrificing historical truth too much if I claim that electricity at rest was the first kind known. This may be wrong from many points of view, but I wish to assume it. It then seems logical that electricity in simple direct motion should later appear and that still later we should find various directions and rates of its motion, if it moves at all. It will interrupt this line of argument if we doubt the existence of electricity as a thing, or question the existence of such different kinds of it as static and dynamic. The electricity of rubbed amber was the first and stationary kind (if you will admit that prior to Thales such things as lightning were something else). When the electricity first moved through metals the process was looked upon as a simple directed flow which proceeded until the charged body had delivered its charge.

Currents

This direct flow of electricity (a current) was strengthened in its hold on our conception by the great number of different chemical current-producers which followed the controversies between Galvani and Volta a century and a quarter ago. Primary and secondary or storage batteries without number were soon discovered. The current from such batteries was exactly like that which the magneto electric machines produced, when these were developed, after Faraday had shown the effect of moving a wire through a magnetic field.

The direct current of such generating machines was much later followed by the alternated flow, and soon alternating current generators were made for different rates of reversal of direction. Sixty, forty and twenty-five cycle currents are now common and the user takes his choice. These frequencies were once accidents of convenience and economy. For some uses other widely different frequencies of alternation are very desirable, as in wireless, where 100,000 cycles are common.

Now the phenomena which have been found in vacuum tubes promise to give complete control over all these details of kind and frequency of current.

Electrical Control

As will be more fully shown later, when a unidirectional current meets vacuum tubes, as though it would pass through them, it must find one particular kind of tube, and the current's direction must be right, because some tubes will let it through only when it is both unidirectional and in the proper direction. These in themselves are rather remarkable things to expect of a vacuum, but as usual, the truth exceeds the expectation.

Catalysis

To give some idea of the extent to which vacuum studies may affect remote fields, let me mention chemical catalysis, the secret of most reactions of life. For example, it is known that mercury vapor in a vacuum, when illumined by light of a certain wave length, will absorb that light and turn the energy over to hydrogen, if hydrogen be present, so that this, in turn, will chemically reduce such substances as cold copper oxide. Here is a new kind of chemical process. It is the kind we have needed in order to begin to explain some of those life-reactions which vegetation discloses. That is, similar facts will probably be found to contain the explanation of the catalytic action of sunlight on growing plants.

High Vacua

Electric currents through vacua where gas is so completely removed that it has no appreciable action are more strictly a part of my present paper. After the work by which the individual and indivisible negative electrical charge or electron was defined, it seemed quite fitting, though unexpected, to learn that these negative charges were exuded by hot bodies. The result of this disclosure formed the basis for most of the modern electrical phenomena in vacua. The activities of electrons are apparently the cause of most electrical and chemical processes. Their motions constitute electric currents and the currents are determined and controlled by voltage or potential difference.

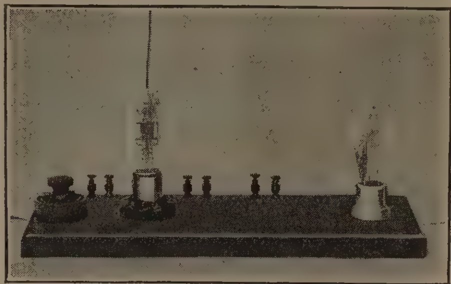
If a house-fly climbs up a window pane one inch he does a definite amount of work in lifting his body that much. If this work constituted the supply fed into the wireless tube from space it would suffice continually to actuate the outfit for a quarter of a century.

Lamps

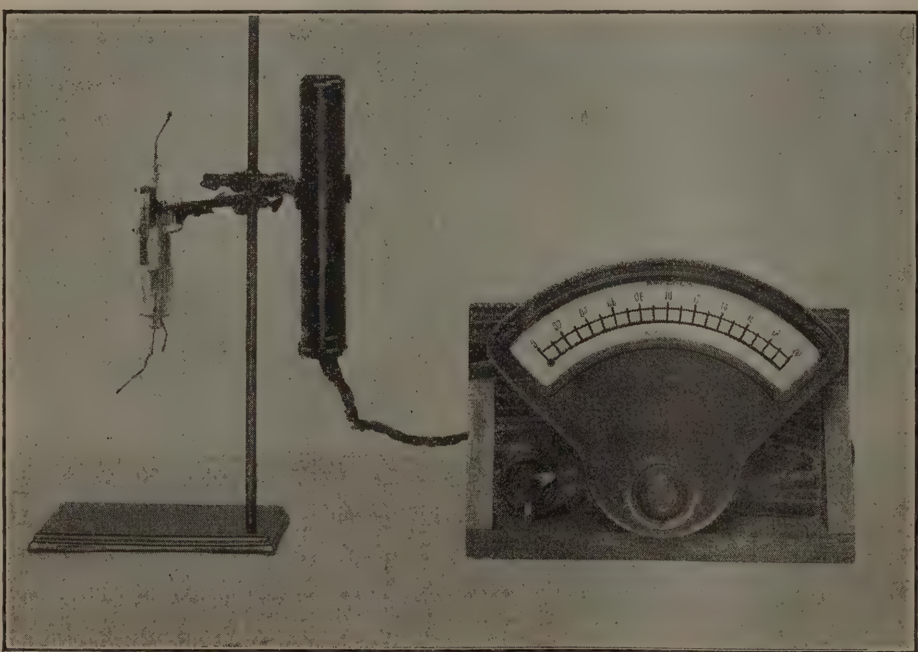
Now for some experiments. The first great use of vacuum was in incandescent lamps. I burn out an ordinary tungsten lamp by raising its voltage very much above normal. It lasts for a few minutes only, but it gives a light perhaps five times as efficient as we usually see. The lamp dies because the tungsten vaporizes or melts. The vacuum is not at fault. It is because of these limitations that commercial lamps are so made that they burn at normal voltages on proper circuits an average of one thousand hours. If we were satisfied with a shorter life we could have a more efficient light, but experience has shown that we would be unwilling to submit to short life lamps in order to have the added efficiency. To lengthen the life of lamps much study has been made of distillation of metals in vacua, and of methods for returning the distilled metal to the filament. Much has also been done to make the deposit on the glass invisible or white, so as not to interfere with light transmission. Naturally, we are always on the lookout for metals, such as the newly discovered hafnium, which might possibly live longer as filament than tungsten now lives. Thirty or forty years of research work had been spent on high vacuum incandescent lamps before Dr. Langmuir showed us how to make still better lamps by putting back into the vacuum gases like argon and nitrogen.

Distillation

When the material of a filament distills in vacua it does not meet interference to the motion of its molecules, and the distilling substance proceeds in straight lines from the heated source. This is often observed when an incandescent vacuum lamp arcs or burns out. Metal shadows of interior parts of the lamp are then often cast upon the walls. This is shown more clearly when a metal like gold is evaporated from the surface of a tungsten filament in vacuum. By interposing a design (in this case a star) the shadow in gold was cast on the glass. This simple phenomenon is mentioned because it fits in with the kinetic theory of gases and explains many things observed in vacua. The "mean free path" of molecules or atoms is very long in good vacua, and so straight line distillation occurs.



This spectacular experiment illustrates grid control in a striking fashion. An incandescent lamp illuminated by the plate current of a radiotron was extinguished by the approach of a charged piece of insulating material to the upright wire connected to the grid.



The current through a coil of wire wound around a cylindrical two-element vacuum tube may, by its magnetic field, prevent the electrons from reaching the plate. In the tube shown the magnetic field is made equal to that of the earth, and by rotating the tube the two fields may be brought into combined action; the milli-ammeter showed various currents. The intensity and the direction of the earth's magnetic field is thus determined.

Hittorf

In the historic Hittorf experiment two vacuum bulbs, each carrying an electrode, were joined together by two glass tubes, one very short and one exceedingly long. When electric current was passed from one bulb to the other it evidently chose the longer instead of the shorter path, because the longer tube became highly luminous, while the shorter one did not. This is a quality of electrical conduction in vacua where small quantities of gases still remain, but it cannot be gone into here.

Edison Effect

The historic Edison effect was discussed and its relationship to pure thermionic currents shown. Where it was once thought that nearly visible particles of the filament were shot across the space between filament legs in vacua, now we recognize in very high vacua only the unidirectional motion of negative electrons.

Rectifiers

In vacuum tubes like the kenotron these electrons pass from the hot filament to an electrode commonly called the "plate." This pure emission current is the basis for the so-called rectifiers because only when the filament is negative does any current flow across the space. When gases are present greater currents may be carried, because by the ionization of the gases the moving electrons produce new conductors from the gas molecules. Thus the tungar rectifiers, containing a little argon and the older mercury vapor rectifiers, involve the same principle. Without some gas present the negative electrons, by their very concentration, constitute a space charge which limits the current. This space charge is removed by the ions produced within the gas when present.

Radiotrons

When we interpose a grid or wire screen between the hot filament and the plate of the two-electrode tube or rectifier, we have what we now so commonly use in wireless for receiving, for amplifying and for production of high frequency currents. The discovery of the controlling or triggering action of the third or intermediate electrode was made by De Forest. A negative charge applied to this electrode or grid interrupts or modifies the electron stream, the current, from the hot filament to the plate. As it takes almost no energy to charge this grid (little more than a "token" of energy, voltage), the slight power from a wireless antenna in its fluctuation may be used to control or to trigger, or to let through corresponding jolts of greater energy, which are in turn supplied by some local battery. In the experiment shown, an ordinary incandescent lamp was lighted by current which was passing through a three-electrode tube from hot filament to plate. Its light indicated this current. The grid, or antenna-wire, was sticking up from the tube so that it could "pick up" electric charges from space. A small negative charge was produced on a rod of insulating material by merely rubbing it with a piece of paper. The charge so produced caused the lamp to go out, or light up, as the charged rod was brought near to or removed from the exposed end of the grid wire.

(Continued in our next issue)

Making a Hughes Induction Balance

THE Hughes induction balance is an apparatus seldom found in an experimenter's workshop. This is probably because the instrument and its uses are not as well understood as those of the more common apparatus. One particular application for the balance is in the detection of counterfeit coins, as in Mr. Benson's story of the Wireless Wiz. It is also possible to compare the strength of magnets, the conductivity of metals, the sensitivity of telephone receivers, or to measure the difference in frequency of two alternating current circuits.

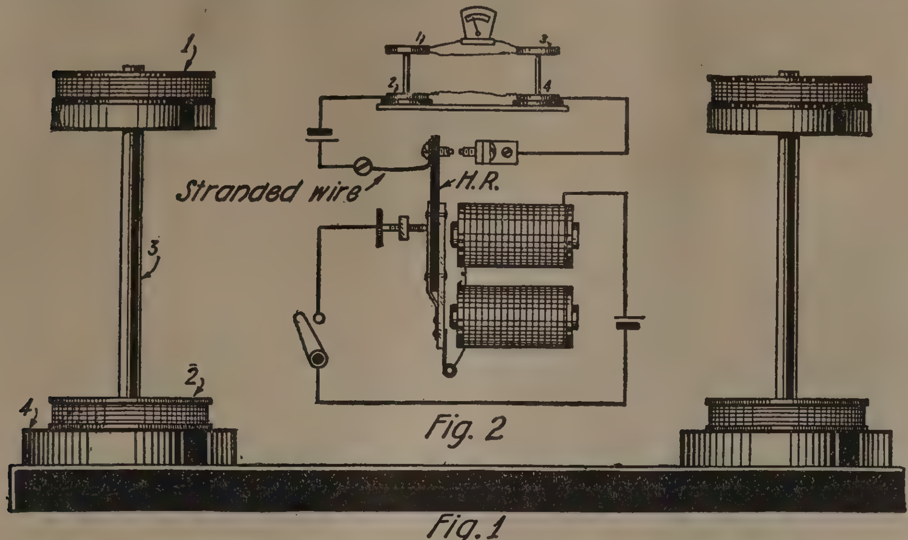
The induction balance is composed of four coils, two in the primary and two in the secondary circuit. When the relative positions of the coils are adjusted correctly the inductances neutralize each other and no current flows in the secondary circuit. If, however, the slightest change is made in any of the coils, such as by the insertion of any metal object, the mutual induction is unbalanced and a sound is made in the telephone receiver.

A balance for use in detecting counterfeit coins is pictured in Fig. 1. Two of these stands are required for the apparatus. Each spool is 3½ inches in diameter, wound with exactly 300 turns of No. 32 single silk wire, spaced evenly, layer on layer. Any difference in the windings will cause trouble when the coils are adjusted. A circular wooden piece ½ inch thick is glued to the underside of spool 1. In the piece is a ⅜-inch hole, making a tight fit on the upright 3. No nails or clamping screws can be used, as this upsets the induction balance. The base is large and heavy enough to support the upright and spools. Lead wires, about two feet long, are used to connect the coils.

Fig. 2 is a diagram of connections. The secondary coils are connected in series with a galvanometer. An experimenter who has no galvanometer can purchase an inexpensive Weston ammeter. When the shunt has been removed this will serve very well as a galvanometer. Some form of interrupted primary circuit is necessary to induce currents in the secondary. An interrupter, mounted on the armature of a buzzer, serves for this purpose. When the key is closed the interrupted primary circuit induces a current in the secondary, causing the galvanometer to deflect until the inductances are evenly balanced.

To balance the circuits so that the inductances neutralize each other and there is no deflection of the galvanometer, it is first necessary to make sure the secondaries are placed on the uprights with the windings in opposite directions to the primaries. This done, the coils are carefully moved up and down until the needle of the meter is at zero.

For detecting counterfeit coins a genuine coin is placed in the hole through one secondary coil and the apparatus is balanced. Any other good coin of the same size will also balance the inductance, but if a counterfeit is inserted there will be a deflection of the indicator, or a sound in the telephone receiver.



Experimenters will find an endless source of instruction and entertainment in the Hughes Induction Balance, illustrated above. It can be used for the detection of counterfeit coins, the comparison of magnetic conductivities of metals, comparison of the thickness of the walls of closed iron vessels, and numerous other tests.

When the difference in frequency of two alternating currents is measured, one circuit is connected to coil 2 and the other circuit to coil 4. The current in the secondary coils will give beats; that is, the sound will grow strong, then weak. The number of beats per second is the difference in the frequency in cycles.

Interesting Articles to Appear in January Issue of the Experimenter

Experimental Detector and Two-Stage Amplifier
By Leon L. Adelman

Wave Telephony Explained by Mechanical Example

110-Volt D. C. Line Replaces "B" Batteries

Mechanically Depolarized Primary Cell
By Earle R. Caley, B. Sc.

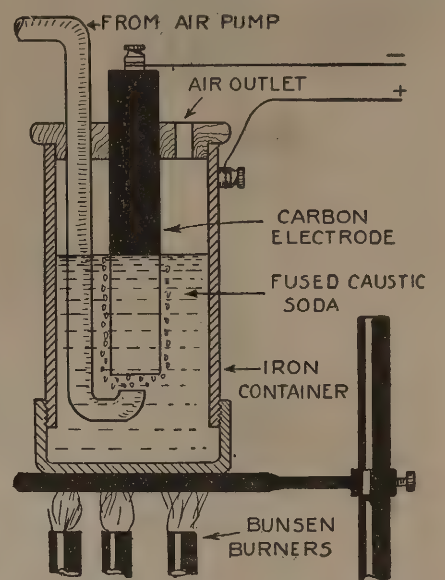
Experimental Microphone and Transmitter
By Raymond B. Wailes

Model Carbon Cell

By Earle R. Caley, B.Sc.

MANY inventors have attempted to construct primary cells in which carbon would be consumed rather than zinc or some other metal, thinking thereby to generate electrical power cheaply in a direct manner. If carbon could be utilized in a primary cell with the same efficiency that zinc is, such a cell would yield ten or twelve times the amount of available energy present than is obtained from carbon in the form of coal as used in the average steam generating plant.

The most promising of all the attempts to generate electricity in this manner, and one that aroused considerable discussion at the time, was a cell invented by W. W. Jacques in the latter part of the last century. A working model of this cell can be readily made by the electrical experimenter and such a cell is shown in the illustration.



Experimenters with a taste for strange apparatus should try this "wet" cell which functions through the simultaneous operation of Bunsen burners, an air pump and a chemical reaction.

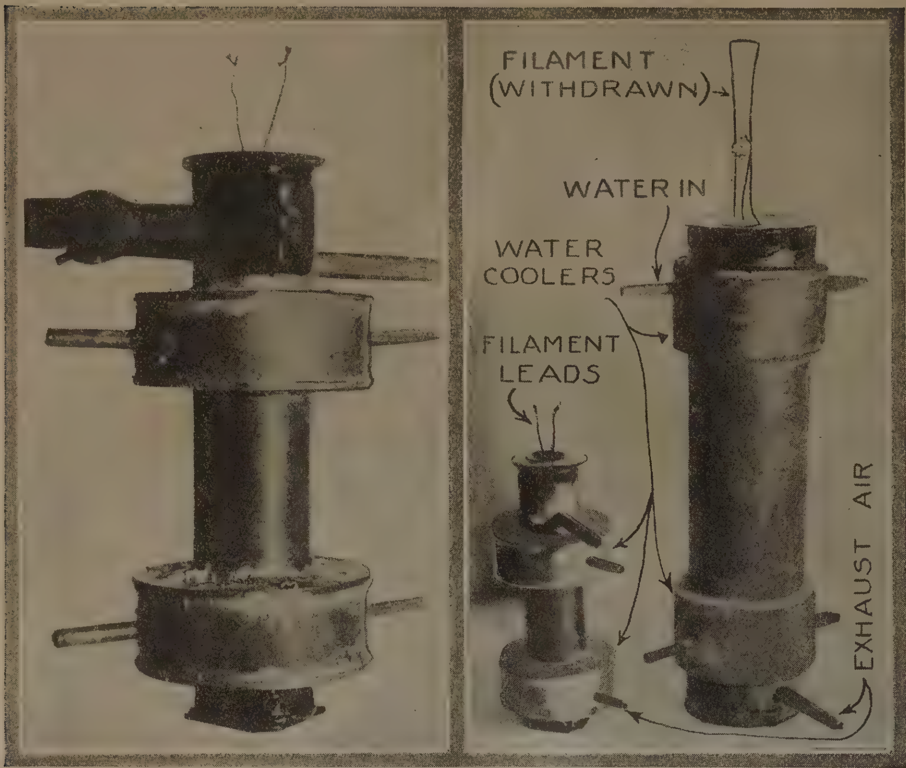
One electrode of this cell is an iron vessel which also serves as the container for the cell. The other electrode is a rod of carbon that dips into an electrolyte of fused caustic soda kept molten by Bunsen burners. Air is blown in upon the bottom of the carbon rod by a tube leading from an air reservoir or an aspirator pump. The iron vessel used may be a cast-iron one such as a glue pot or similar vessel. The use of an ordinary tin can is inadmissible on account of the soldered seams. A section of three-inch pipe capped at the end makes an excellent container for this purpose. The carbon electrode, which may be an ordinary battery carbon, is fitted into this by means of a turned wooden disc as shown.

The pipe for conveying the air to the bottom of the cell may be made from flexible copper tubing or else from one-quarter-inch gas pipe capped at the lower end and having several fine holes drilled in this cap so as to allow the air to spray upon the carbon. A hole is drilled near the top of the iron container to receive a brass binding post. Air may be supplied from a bicycle pump or preferably from a small tank that is filled from time to time by the pump.

To operate the cell it is filled about half full of caustic soda (ordinary commercial lye will do) and then mounted on a ring stand or a similar holder and heated by several Bunsen burners, or some other good source of heat. As soon as the fused electrolyte has attained a temperature of 500 degrees C., 932 degrees Fahrenheit a gentle stream of air is blown into the cell. A current will then be generated and an E. M. F. of about one volt.

Building a Power Vacuum Tube

By Dr. Russell G. Harris



The apparatus on the left are home-made power vacuum tubes, ingeniously assembled from iron pipes and the anchor leads of burnt-out incandescent lamps. The necessity for the water coolers testifies to the magnitude of the power delivered by them.

A pair of anchor leads with filament mounted is shown above. The anchor leads represent the plate of the regular vacuum tube.

THE general directions which follow will serve in building a rectifier tube for charging A and B storage batteries, a Fleming valve for detecting, a soft three-element tube, or an interesting source of light. There is no reason why it could not be made into an amplifying tube or a power oscillator as well, the success in each case depending on the trouble the experimenter cares to go to.

Many radio fans have attempted to build vacuum tubes, but the greatest obstacle has always been in the glass blowing. The writer built his first tube years ago out of a piece of iron water pipe, and made all joints with sealing wax, so that no glass blowing was required. This was done because in the experiments in progress it was necessary to burn out the filament every few hours, and in this way it could be easily replaced. When this first iron pipe tube was built, the obvious thing was to let the pipe itself form the plate. In those days this was quite unorthodox, but modern high power tubes are being built in this way so that the plates can be water cooled. Therefore, in resurrecting this old makeshift form of tube we are describing something which is right up to the minute.

Since a large amount of power is to be used, if desired, water-cooling is provided for the ends of the tube, so that sealing wax joints can be used. A piece of pipe of the desired size and length is cut, and the ends carefully smoothed. Water coolers are then soldered near the ends, leaving at least half an inch of pipe clear beyond them so as to give room for a flame in melting the wax joints when removing the ends. In the case of a small tube the water cooler may consist merely of a few turns of soft copper tubing wound around the pipe near the ends, but this must be carefully soldered in place, or not enough contact will be made to allow the heat from the pipe to escape to the water.

Near one end of the pipe a small side tube is carefully soldered in, so as to make an air-tight joint, and it is through this that the tube is exhausted. One end of the large tube is then closed with a glass plate sealed on with wax.

For the filament mounting a burned-out incandescent lamp of 100 watts or over will furnish two good anchor leads and a seal. Directly between the ends of these leads the filament is to be put in place by spot welding. This is done by laying about half an inch of filament across the two anchor leads, and connecting one side of a 110-volt line to one of the leads. The other end of the line is connected to a resistance of from 20 to 200 ohms, according to the size of the filament to be welded. Then from this resistance connection is made to the welding tool, which consists of a nail set in a handle. The point of contact of filament and live lead is then lightly touched with the welding tool; a small flash will be seen, and after several trials the filament will be found welded in place. Then the live lead is transferred to the other anchor wire, and the other end of the filament is welded to this. This process is carried out commercially in an atmosphere of hydrogen, but as the latter causes explosions and burns the hair off the hands of the operator, the writer now neglects to use hydrogen and still has good success, though care must be taken as tungsten oxidizes easily. The magnitude of the resistance to be used must be found in each case by trial and error, only the error of using one less than 15 ohms should not be made. Also this resistance should be capable of carrying 10 amperes for a short time.

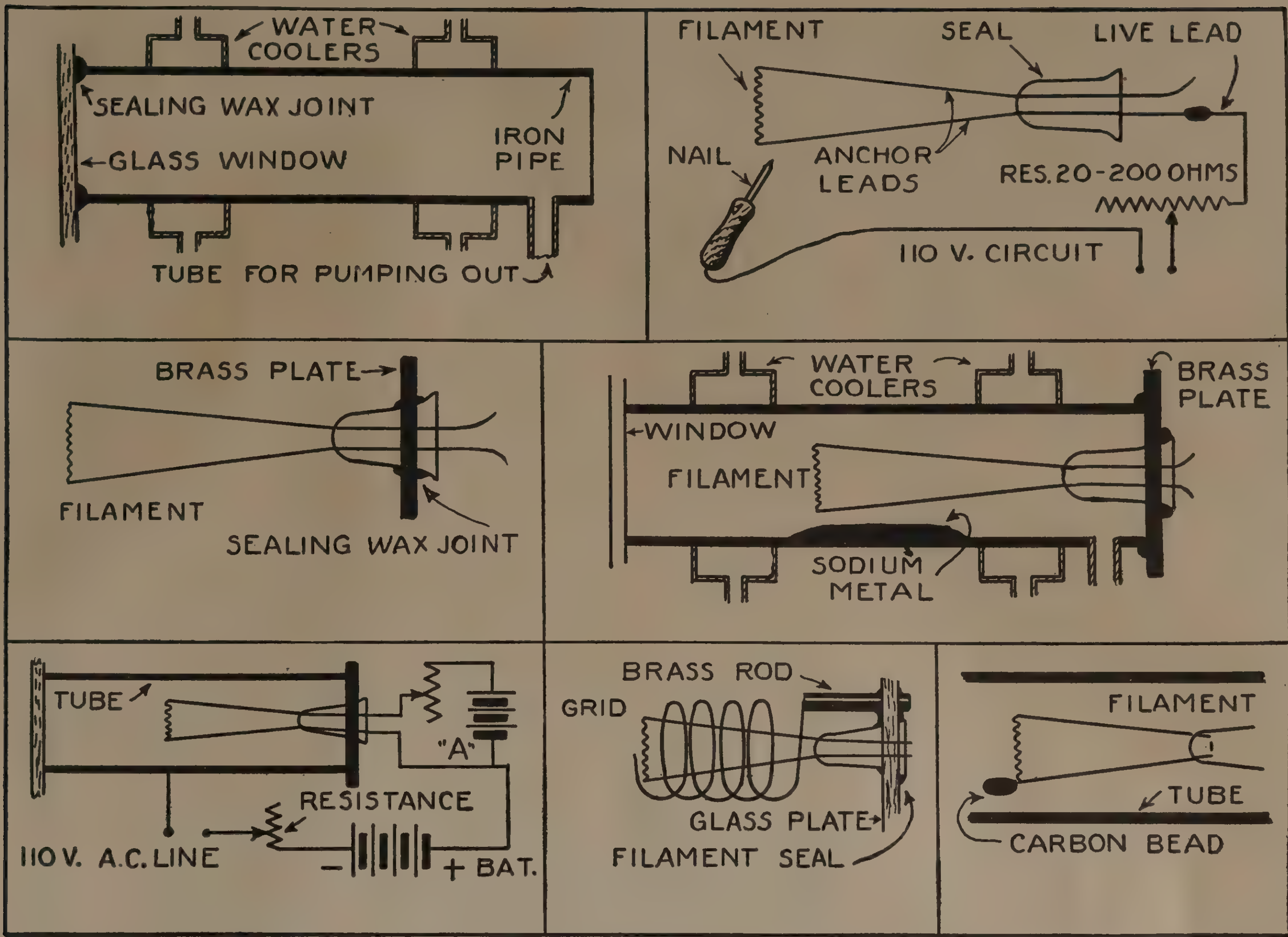
The next point is where to obtain filament wire. This can now be obtained very cheaply on the open market, and by writing to the information bureau of this magazine, one can find where to buy it. If it is not desired to buy it, old incandescent lamps furnish short pieces of various sizes, which are harder to use, however, as they become very brittle after having been burned. Where possible it is best to buy new tungsten wire for filaments.

Before beginning on a three electrode tube it is well to try a simple two electrode mounting. A typical filament mounting as has been described is shown in the illustration; this is then mounted in a hole in a brass plate with sealing wax. This plate is then sealed to the end of the tube with wax, and the tube is done, all except the vacuum.

This point is the hardest, yet there are so many ways of producing a vacuum easily that it is surprising more of them are not better known. The type of vacuum pump known as the diffusion pump, which operates with boiling mercury vapor and gives the highest vacuum obtainable with any pump, is one of the simplest to make when the materials are at hand. Its description must be left to a future article, since no such high vacuum is desirable in the present case; and since this pump requires a force pump to take away most of the air before it begins pumping, this force pump will serve for the present work.

The particular type of vacuum pump to be constructed and used will depend largely on the apparatus at one's disposal. In order to safeguard the filament it is necessary that absolutely no oxygen be present. Hence we may either pump all the oxygen out, or wash it out with some other gas, or pump most of it out and then burn up the remainder before the filament is lighted. The writer used the last method, since it was desired to have sodium in the tube anyway. Hot sodium combines very readily with oxygen, and affords probably the easiest means, but it must be carefully handled. Sodium metal is not expensive, but it must be kept away from water. The sodium should be kept in a closed jar except when a piece is taken out to be put into the tube.

A simple vacuum pump can be made by reversing the washers on the plunger of a bicycle pump. A stopcock should be put into the line, for which a heavy walled rubber tube should be used, or else a thin one wound with wire to prevent collapsing, and after the air is pumped out of the tube as far as possible, opening and closing the stopcock with each stroke, the latter is left closed and the tube allowed to stand for several hours to test for leakage. If it still shows a vacuum at



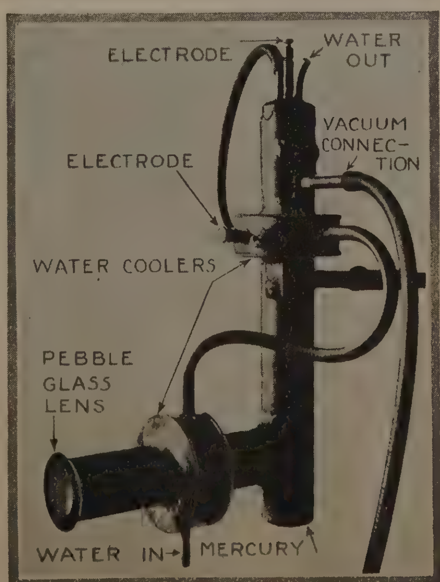
These detailed drawings remove many difficulties in the construction of the power vacuum tubes. Besides structural details the diagram indicates an interesting method of evacuating the tube. By heating sodium in the tube the residual oxygen is finally removed.

the end of that time, pump as much more air out as possible, close the stopcock, and gently heat the center of the tube where the sodium has been placed, to melt it. Be sure the water coolers are acting. Once the sodium has been well melted you may be sure there is no more free oxygen. Current may then be turned on, igniting the filament, and its heat will keep the sodium melted and take care of any further oxygen that leaks into the tube. The pump should always be used to partially exhaust the air, however, as otherwise the heat in the tube is apt to raise the pressure inside and push out a window.

The next question is how much current to put through the filament. The experimenter should gradually increase the current until he thinks it is bright enough. Place an ammeter in series with the filament battery, and gradually increase the current until the filament burns out, recording the current required to do this. One should expect to burn out several filaments at first, in order to get experience in replacing them quickly. After the tube has cooled off, turn off the water, slowly let in the air, and melt the sealing wax around the filament end of the tube. This can then be removed bodily, and a new piece of filament wire welded in place. No new sodium will be needed, as a small lump will last a long time. Upon reassembling, testing for leaks, etc., the tube is as good as new. Practice enables one to do the whole job of replacing a burned-out filament in a few minutes.

The filament should be regularly run at a current about four-fifths of the burn-out current, unless the burn-out was caused by oxygen in the tube. The writer often uses filaments for one purpose which burn out at 8.5 amps., running them for many hours at 6.6 amps. But if care has not been taken to get rid of all the oxygen first, these will burn out immediately at four amperes.

Now connect the apparatus as in the diagram for a rectifier, first applying about thirty volts in series with a resistance to the tube, being sure to get the "B" battery voltage on the pipe, and the negative one of the terminals. If a galvanometer with milliameter shunt is now placed in the plate circuit, a current should be found flowing. Finally, if the 110-volt A. C. line is placed between plate and filament, in series with a resistance, only one side should get through. Batteries can then be charged by putting them in the circuit as illustrated.



This shows a vacuum mercury arc lamp with quartz lens for emitting ultra-violet rays.

This type of tube should never be used without a resistance in series with the plate, as a short circuit is apt to occur inside it, due to spattering of the sodium; also its internal resistance is very low, as evidenced by the fact that in one case 20 amps. was forced through by a 110-volt "B" battery, making an internal resistance of half an ohm, as compared with many thousands of ohms in the ordinary tube.

The space current which attains such large values in this tube is not due to electron emission from the hot filament alone, but also to ionization of the sodium vapor, as there are many positive ions as well as electrons in the space charge. These tend to neutralize each other, and hence large plate currents occur, as is characteristic of soft tubes. And of all tubes, this is the softest!

Now we are in position to add a third element, the grid. This can be built up like the filament, out of sheet iron or nickel and wires of these metals welded together with the spot welder. This is mounted on a separate lead, as in the drawing. Also an extra plate may be added, if it is desired to have a smaller one than that furnished by the outer casing. The elements are built upon an insulating plate of glass, and fastened in place with sealing wax. Some slight practice is needed to make wax joints airtight, but if it is remembered that any piece of metal or glass should be heated gently almost up to the melting point of the wax before any is applied, an airtight joint will practically always result.

A different type of tube can be made by substituting a bit of calcium metal for

(*Continued on page 139*)

Home Made Mercury Vapor Vacuum Pump

By Dr. Russell G. Harris

IN this article will be described two simple forms of mercury vapor vacuum pump which are constructed of materials obtainable by the average experimenter without much trouble. These pumps are based on those forms of mercury pump which have given the highest vacua ever reached, and which are commonly used in commercial work where vessels must be emptied of all gases and vapors as completely as possible.

There are numerous experiments which can be performed with apparatus of an electrical nature which are beyond the range of the average person because he has no way of producing a high vacuum. The home-made power vacuum tubes described in a recent issue of this magazine can be made into regular oscillator and modulator tubes with the aid of one of the pumps to be described. Besides exhausting luminous discharge tubes, home-made incandescent lamps and mercury vapor lamps which are to be described in a future article, many other uses will immediately suggest themselves.

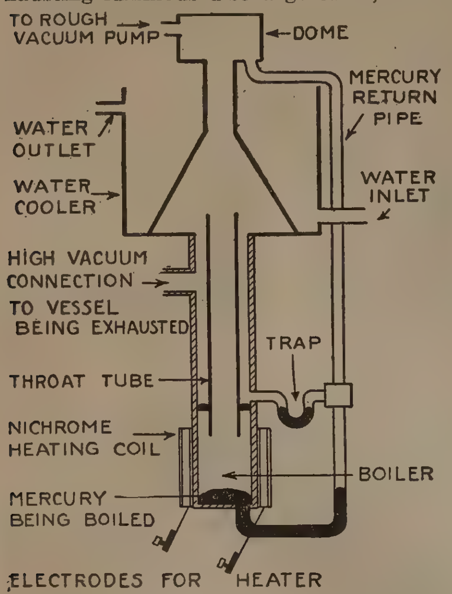


FIG. 1

The mercury condensation pump here illustrated is a simple experimental replica of the famous Langmuir pump with which a pressure as low as 0.0001 mm. of mercury can be obtained.

With either of the two pumps to be described, pressures so low that they could be measured have been obtained. Anyone who builds one of these pumps, together with a simple manometer and a rough pump to use with it, together with suitable stopcocks, will have a high vacuum outfit surpassed by few commercial pumps. Modern physics is using the vacuum more and more, and a high vacuum pump is part of the equipment of every good laboratory.

Kamerlingh-Onnes, the Dutch physicist who has approached to within a fraction of a degree of absolute zero in temperature, used a battery of 20 or more of these pumps connected in parallel to produce rapid evaporation of liquid helium. Some physicists use several of these pumps in series, so that one pumps from the pressure of the rough pump down to say one hundredth of a millimeter pressure, the next down to a millionth of a millimeter, and so on.

Generally when a high vacuum pump of this type is constructed in the laboratory it is blown of glass. Most experimenters have no facilities for glass-blowing, however, so the first pump described is designed so as to be entirely constructed of metal. This does not make it imperfect, since the commercial form of the famous Langmuir pump, on which this one is based, is built of steel.

The shell of the pump is illustrated in Fig. 1. The boiler consists of a piece of two-inch pipe, or better, of two-inch steel tubing, about seven inches long. This is plugged at the bottom with an iron cap. All joints in the pump should be carefully welded, as brazing is attacked by the hot mercury vapor. Similarly, no brass tubes or pipes can be used in the interior construction of the pump. After the various parts of the pump have been fitted together they should be taken to a garage or welding shop, for all the parts to be carefully welded in place. Caution should be given the welder that all joints must be vacuum tight, and an expert will have no trouble in making them so.

A side neck of pipe or tubing not less than three-quarters of an inch in internal diameter is welded to the side of the mercury boiler three inches from the top. This is the tube to be connected to the vessel to be exhausted, and may be made as long as desired. Ordinarily it will be about a foot long, and the tube connecting it to the vessel being exhausted may be sealed to it with sealing wax. The larger it is, the faster the pump will work.

On the inside of the boiler the neck is welded in place, as in the figure. This is probably most easily done by fastening the neck to a piece of pipe which fits snugly inside the lower part of the boiler.

On top of the boiler is welded the condensing cone, cut from a fairly thick piece of sheet iron, and the seam carefully welded. On top of this is fastened the dome neck, and on this the dome.

Now the water cooler should be put in place, before any of the side tubes are welded in. This may be made of brass, or an old tin can will serve, so long as it will hold water. Two water tubes are soldered in it, and it is then soldered to the boiler. It may be slipped on before the lower tubes are welded, and then soldered after this has been done. Be sure to have the water enter the lower inlet and leave the upper one, so that the cooler is always full. This enables the cone to condense the mercury vapor, and on this action the value of the pump depends.

Now the side tubes can be put in place. These are made of seamless steel tubing, fairly flexible, and about a quarter of an inch in diameter. Do not omit the small U-bends in these, since they furnish a mercury seal to keep the tubes from short-circuiting the main action of the pump. The side tubes drain the mercury from the pockets where it condenses and let it run back to the lower reservoir.

Finally the bottom of the boiler is covered with mercury to a depth of about a quarter to half an inch, and the lower part of the boiler is wound with several dozen turns of nichrome wire, about No. 20, insulated from it by a layer of mica, for the heating element. Be sure to use some resistance in series with this wire before attaching it to the 110-volt circuit; in the final form it should be wound so as to show a bright red, when covered with asbestos and connected direct to a 110-volt line. Preliminary tests with the pump can be made, however, by merely heating the boiler on a gas plate or with a Bunsen burner. After the mercury has begun to boil vigorously the flame should be turned down so as to just keep it boiling. Never heat the pump without having the water running in the cooler, or when the pump is open to the atmosphere, as the mercury will not only quickly boil away but mercury vapor is very poisonous.

This type of pump always requires some kind of a backing pump. That is, although it will pump out a closed vessel so that the pressure goes down to say a hundred millionth of an atmosphere, it will not do it from atmospheric pressure, but only from about one-eightieth of an atmosphere downward. So a rough pump, called the backing pump, must be used to first partially exhaust the vessel. Any sort of an oil pump will do, or an ordinary bicycle pump with the plunger turned around so that it sucks air instead of pushing it, and connected to a glass bottle which is kept pumped down to a certain pressure. The vacuum in this bottle should always be kept below half an inch of mercury as measured by a manometer to be described.

The final set-up necessary for the proper use of the pump is given in Fig. 2. The pump is shown connected to a glass vessel being exhausted through a mercury trap, which is desirable but not absolutely necessary. The joint is made with sealing wax, and all tubes may be of metal if glass is not available. A mercury manometer should be made of a piece of glass tubing about a quarter inch in diameter and a foot long, sealed at one end and bent into a U. This is connected into the rough vacuum circuit containing a bottle about the size of a two-quart jar, and the rough pump. The U-tube is partly filled with mercury which is then run around so that no air remains in the sealed end, and inverted.

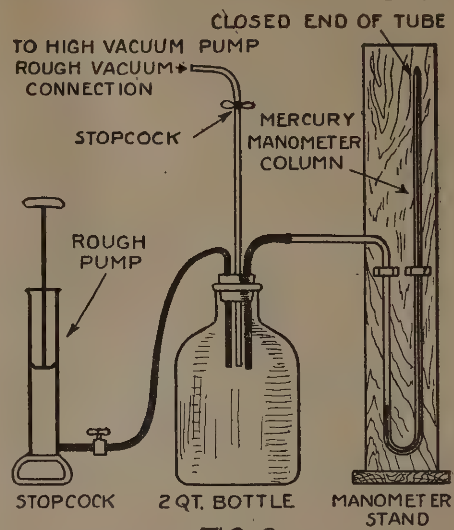


FIG. 2

The condensation pump at the right must be "backed" by a rough pump, a very simple and satisfactory form of which is shown above. A closed tube manometer serves as a pressure gauge.

As long as no vacuum exists in the line the column of mercury in the closed arm of the U will stand higher than that in the open arm. But as soon as the vacuum gets down to a certain point the mercury will begin to fall in the closed arm, and at a perfect vacuum the two arms will be exactly even, provided no air was allowed to remain in the closed arm. The degree of vacuum is measured by the difference in level between the two mercury surfaces in the manometer, and for the proper operation of the mercury diffusion pumps being described this should be kept less than half an inch if possible. There are a number of easily built rough pumps which will do this, but a description of

one must be reserved for a future article. The high vacuum pump is described first because few experimenters possess one, whereas many have a rough pump which will easily pump down to half an inch mercury pressure.

Stopcocks should be placed in the line at certain places; these can be purchased made of glass, or can be constructed of shop materials, several types having been described in this magazine. Where nothing else is available, if rubber tubing connections are used (these serving where not more than one hundredth thousandth of an atmosphere vacuum is desired) ordinary pinchcocks screwed up on the tubing will prevent leakage. These should not be screwed up so tight that they cut the tubes.

The second type of pump is somewhat easier to construct provided a small amount of glass blowing can be done. It is not only a high vacuum pump but a mercury arc and a mercury still as well. It is shown in Fig. 3.

The two glass tubes at the right should be about 30 inches long, but they may be as slender as desired, as may that at the other end. The tube to which they are fastened at the top should be over an inch in diameter if possible. They dip into two small bottles such as ink bottles, which contain the original mercury to be distilled and to run the pump. The joint between the end of the tube and the metal water-cooling jacket, the inner tube of which should be of iron, must be carefully made with sealing wax, care being taken that the layer of wax between the tubes is very thin and extends for several inches, so that the water will surely keep it cool. The outlet tube is connected to the rough vacuum pump, as in the first pump described. The outlet bottle should have a small amount of clean mercury put into it to act as a seal, sufficient to fill the tube at the left end when the pump is evacuated.

When the rough pump is started a partial vacuum is produced inside the pump and the mercury slowly rises in all three lower tubes. Electrodes of iron wire carefully cleaned of any zinc coating,

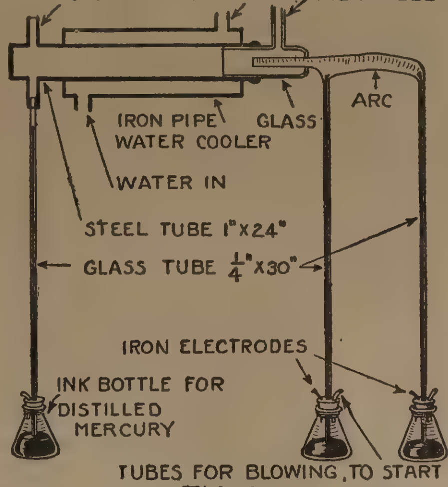


FIG. 3

In this interesting application of the mercury vapor arc to the production of high vacua, the molecules of mercury vapor moving rapidly through a glass nozzle draw "air-molecules" from the exhaust chamber.

having been placed in the two right end bottles, are connected to the 110-volt D.C. lines through a resistance of about 30 ohms. The two mercury columns in the right end tubes are made to join by blowing into one of the bottles momentarily, then blowing into the other, getting up air pressure until the mercury rises into the body of the arc. When this falls back the arc should strike. Mercury will boil rapidly from the arc and pass through the throat tube, carrying with it air entering through the side tube from the vessel to be exhausted. It then condenses on the cool sides of the iron tube, and runs down-hill into the end tube, collecting there and gradually filling the bottle. At the end of a run the mercury from that bottle can be poured into one of the first bottles. The air which the mercury carries along is pumped out by the rough pump, and again as in the first case, a manometer and bottle should be connected to the rough vacuum circuit, and the pressure kept below half an inch difference in the mercury levels.

Care should be taken that not too much current is sent through the arc. So long as the glass does not get soft, everything else is all right. With a large glass tube as much as 30 amperes have been sent through such an arc, only a few volts being needed to do this, and the pump acted very rapidly. This arc may be run on a six or twelve-volt battery with a small resistance in series for starting, provided the pressure is about right when the arc is struck.

The above pumps, of the type known as condensation pumps, depend on the fact that mercury molecules, when moving rapidly from a boiling surface, carry air or other gaseous molecules with them. They require a certain amount of room in which to work, however, so the real pumping effect does not begin until the pressure gets down to about one-seventy-fifth of an atmosphere. Since the pressure of the atmosphere in terms of the difference in level of a mercury manometer (barometer) is about 30 inches, it is evident that a rough pump must first be used which will get down to less than half an inch pressure.

Nobili's Rings

By Earle R. Caley, B.Sc.

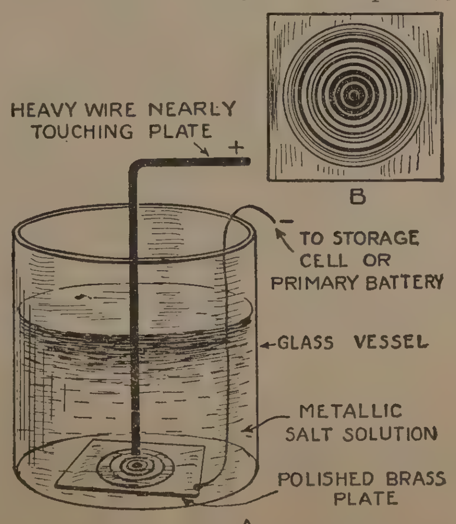
THIS interesting phenomenon of electrochemistry was discovered by Nobili in 1826. In the original experiment Nobili observed that when a drop of a strong solution of copper acetate was placed on a silver plate and the drop was touched in the middle with a pointed piece of zinc there was formed on the silver surface around the point of contact a series of concentric rings of metallic copper, alternately light and dark.

This original experiment can be readily reproduced using a strong solution of copper sulphate (commercial blue vitriol will do), a pointed zinc rod and a surface of silver such as the bottom of a silver-plated dish. Many other solutions of metallic salts exhibit this peculiar phenomenon. By far the most striking and beautiful effects are produced by employing strong solutions of lead acetate, whereby the rings deposited are in the form of shining iridescent circles of lead peroxide which exhibit all the colors of the solar spectrum.

To obtain the most satisfactory results the experiment should be conducted as follows: There is needed, first, a constant source of low voltage. An ordinary six-volt storage battery is excellent, or in place of this an ordinary bichromate plunge battery. The solution used is prepared by dissolving one part by weight of ordinary sugar of lead, or better still, chemically pure lead acetate in five parts by weight of water and then filtering the solution.

The best kind of a surface to deposit the rings on is a silver one. In place of this, however, one of german silver or of nickel-plated brass well polished is nearly as satisfactory. Finally, there is needed a flat dish of some kind such as a chemical crystallizing dish, a small enameled pan or even a deep saucer.

To conduct the experiment the metal plate is placed on the bottom of the flat vessel and connected with the negative pole of the battery. The prepared lead acetate solution is then poured in so as to cover the plate to a depth of half an inch. The other wire from the positive



The beauty of this fascinating electro-chemical experiment is enhanced by the facility with which it is produced, a metallic salt solution and a storage battery being the only requisites.

pole of the battery is then dipped into the solution above the metallic plate and allowed to come within an eighth of an inch of its surface, but not in contact with it. Almost at once the characteristic beautiful rings of lead peroxide will appear. After depositing these rings on the plate it may be rinsed off, dried and kept permanently, since the lead peroxide formed in this way is of a very tenacious and adhering nature.

Instead of using a simple point as the anode, electrodes of varying shapes can be tried. For instance, one may be bent into the shape of a monogram from single cotton-covered magnet wire and then allowed to rest on the plate and yet not be in contact with it. Or a number of short lengths of copper wire placed in evenly-spaced holes in an ordinary board all connected to each other and to the positive pole of the battery will produce a whole series of the rings, which will cause the whole surface of the plate to take on a very beautiful ringed effect. Anodes of many other novel shapes may be devised by the ingenious experimenter. Those in the form of irregularly bent and corrugated plates give highly variegated bands of beautiful colors.

With some modifications this process has been employed to impart to small articles of jewelry beautiful iridescent colors. The French chemist, Becquerel, devised a lead solution by means of which these beautiful lead peroxide films may be deposited on almost any metal or alloy. It is made by dissolving 100 grams of potassium hydroxide in a liter of water, adding 75 grams of lead oxide (litharge) and boiling the solution 30 minutes or more. This solution is then filtered and diluted with an equal volume of water.

The theory for the formation of the films of lead peroxide is relatively simple.

(Continued on page 136)

Simple Electric Transmission of Drawings

By Dipl.-Eng. E. Schroder

THE problem of seeing at a distance is preceded by the presumably simpler achievement of transmitting pictures by telegraphy.

The simplest and most readily understood method of reproducing a picture electrically is by electrolysis. The apparatus which works on this principle is based upon the fact that an electric current which is sent through a solution of metallic salts decomposes them into their

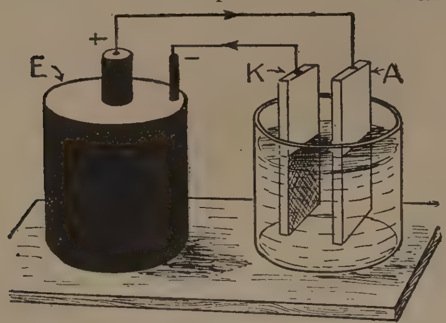


FIG. 1
Illustrative example of electrolytic deposition. The shaded part indicates metal deposited on the electrode.

constituents. Although very many of our radio friends are now familiar by experience with back-coupling and modulated oscillations, reflex operation and similar things, very often the simplest basic laws are quite unsuspected by them, so we can properly show the elementary diagram.

In the right-hand glass vessel there is a solution of copper sulphate in water, in which as electrodes two plates of carbon (A) and (K) are immersed and connected with the galvanic battery (E). Then as the current passes, the beautiful blue solution gives up its copper so that plate

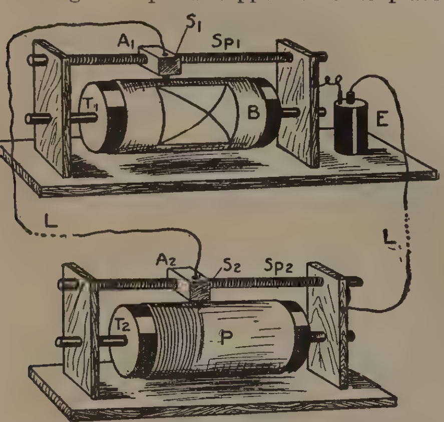


FIG. 2
An elementary form of the sending and receiving apparatus for the electric transmission of drawings is illustrated above. The receiving stylus actuated by the transmitter current reproduces a design on a synchronously driven drum. The two apparatus may be assumed to be many miles apart.

(K) is coated with copper, red and metallic, as indicated by the hatched lines. For producing a picture other solutions are employed; but this simple example is enough to make the topic clear.

Now we must explain the apparatus produced in 1843 by Bain, but first put into practical form in 1847 by Bakewell. In the diagram Fig. 2 the sending apparatus is shown above and the receiving apparatus below, may be assumed to be at any distance: The design to be transmitted, which may be writing or drawing, is painted upon a plate of metal such as tinfoil, with an insulating paint or varnish such as asphalt or shellac solution. As a simple example we show here a square crossed by its two diagonals. This leaf of tinfoil is then attached to the cylinder (T_1) and may be cemented thereto.

On the surface of the covering of the cylinder a metallic stylus (S_1) rests, whose insulating arm (A) is tapped with a thread at its back and through which passes the lead screw (Sp_1). The current of the battery (E) is conducted to the right-hand standard and the shaft, then through the drum (T_1), and then passes through the stylus point (S_1) when it is possible to do so, which is when the said point rests upon an uncovered portion of the tinfoil covering (B) of the cylinder. But when the point (S_1) reaches a part of the foil covered with the insulating pigment the current is cut off. Now if we turn the cylinder (T_1) on the shaft, while at the same time the point (S_1), by the action of the lead screw (Sp_1) is slowly drawn along the cylinder parallel to its axis, the point (S_1) will then cover the surface of the tinfoil with a discontinuous helical line whose successive lines lie close to each other. The drawing will therefore be transmitted step by step and decomposed, as it were, into openings and closings of the circuit.

The next diagram shows the way in which this apparatus was constructed and a model made by Bakewell, which was driven by a clock spring.

But now the current thus produced must act upon the distant receiver and give us visible lines again. For this purpose the same arrangement as the transmitter is employed, including the metal drum (T_2), a metal point (S_2), and the transferring point (St_2). It is essential that the receiving apparatus shall move at exactly the same speed as the transmitter. Then we will find the stylus point (S_2) on the same portion of its drum (T_1), always in place corresponding to the receiving apparatus drum.

The technician will express this by saying that both apparatus must be in synchronism. Now we wrap around the drum (T_2) of the receiver a sheet of bibulous paper (P) which has been moistened with a colorless solution, from which the electric current, just as it did with copper sulphate solution, will separate a definitely colored substance. Thus a ferrocyanide (as yellow prussiate of potash) mixed with ammonium nitrate and dissolved in water will give a dark blue color under the action of the current. The current transmitted in regulated intermission according to the lines of the drawing is carried through the corresponding parts of the receiving apparatus, including the moist paper spread upon and attached to the drum or cylinder.

It follows that the point (S_2) will reproduce on the paper in blue lines the design painted upon the tinfoil at the distant transmitting station. This will perfectly reproduce the design from the tinfoil, giving a point wherever the original drawing had a line, and will be broken off wherever the insulating composition comes. Now when the paper which has covered the entire surface of the cylinder (T_2) is unrolled and spread out we will have a perfect reproduction of the original, in white upon a blue surface, the

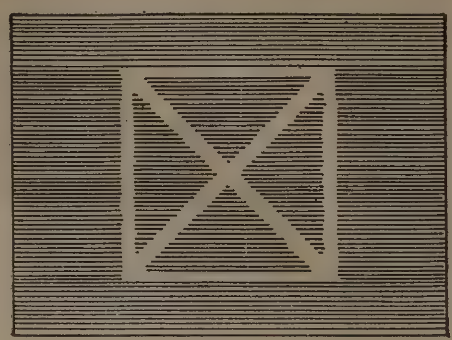


FIG. 4
The received drawing is a "negative" of the drawing on the transmitter drum, since the receiver stylus is lifted off the drum when the transmitter reaches point after point on the drawing.

latter composed of lines in close proximity to each other, as shown in Fig. 4. The above is electrochemical reception.

We have come to the important development of receiving a sketch or writing by the use of the electromagnet. We now refer to Fig. 5. The transmitter is of exactly the construction described for the preceding case. Again we find in the receiver a cylinder covered with paper,

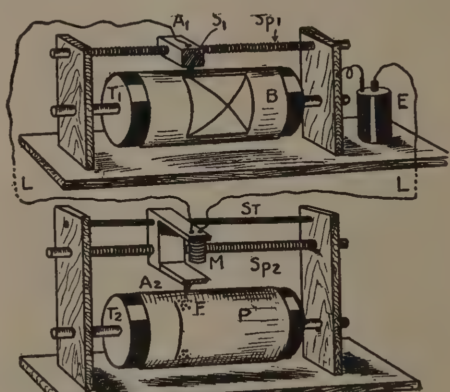


FIG. 5
The type of apparatus shown above operates by a positive action of the receiving stylus, the latter making a mark on the receiver drum when the transmitter circuit is interrupted by lines of the drawing.

but the metallic stylus is replaced by a pencil or a sort of fountain pen carried by an arm (A_2), which can be raised by an electromagnet so as not to touch the paper. A second bar (St) parallel to the lead screw (S) insures the position of the arm carrying the electromagnet, armature, stylus and movable arm.

When the magnet is passing no current the reproducing point bears with its weight and that of the armature upon the drum, and if this is rotated the same helical line will be drawn upon the paper. Now let the current from the battery be interrupted at proper intervals by the transmitter, which current goes through the coils of the electromagnet (M), it will raise the arm (A_2) and lift the inscribing point from the paper. This occurs as long as the stylus of the transmitter rests upon the insulated varnish on the tinfoil. But

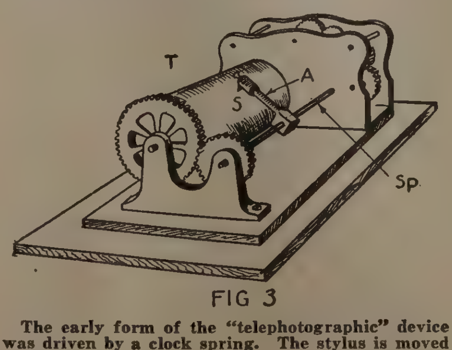


FIG 3
The early form of the "telephotographic" device was driven by a clock spring. The stylus is moved transversely by a threaded rod or lead-screw geared to the drum shaft.

when at the transmitter any point of the design opens the circuit, the magnet (M) releases the inscribing point (F) so that it makes a mark upon the paper. By this apparatus we obtain the sketch reproduced in points and strokes lying very close to each other in tint or color upon a white ground, Fig. 6.

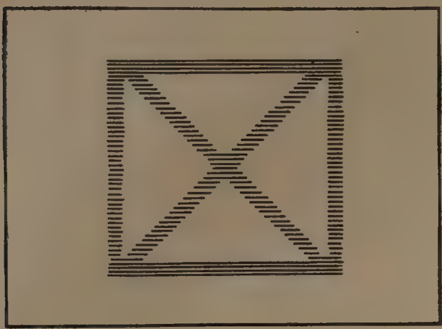


FIG. 6

A "positive" reproduction received on the apparatus shown in Fig. 5 is illustrated above. This is an exact duplicate of the transmitted drawing.

The two apparatus so simply described are subject to many modifications, but these do not affect the basic principles. Thus a departure is shown in the transmitter of Hubert, in which the design is produced on the paper in relief, so that the lines rise above the surface of the paper. The current by the contact (K) is carried to the receiver. But this is only possible when the stylus (S_1) is raised by the relief portion of the sketch and the movable arm (A_1) pressed against the contact point (K) beneath which is a light spring for the purpose of making a good connection.

The current thus made intermittent produces on the chemical receiver the sketch in blue lines on a white ground, and with the electromagnetic apparatus in white upon a ground of parallel lines as shown in Fig. 4.

This has been described in the simplest possible way, but picture telegraphy cannot be carried out as smoothly as all this. Thus the greatest difficulty inheres in establishing synchronism; that is to say, identical speed of the two drums (T_1) and (T_2), which, of course, may be many miles apart. This is a complication which cannot be treated of here.

The question of the speedy transmission to be obtained by such an apparatus is of interest to us. If we have regard to the disturbances in the current, due to capacity of the circuit, self-induction, lag of the electromagnet and similar factors, which are bound to occur, but which with our present means we can well overcome, we can then under the most favorable circumstances produce 300 points per second.

A picture 3½ × 5 inches reproduced in points 100 to the inch will require some 170,000 points, so that if this is divided by 300 we will have 570 seconds, or nearly

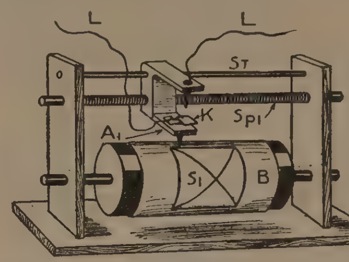


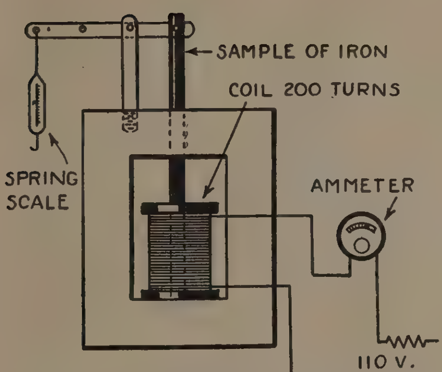
FIG. 7

This modified form of "telephotographic" transmitter operates with the drawing to be transmitted formed in relief on the paper. The transmitter circuit is closed when the stylus is lifted by the raised portions of the drawing.

ten minutes required for the reproduction. But this time will have to be increased if we consider the delay due to difficulties in establishing synchronism.

Magnetic Density Test

By Herbert L. Moershfelder



This apparatus, readily constructed, will enable the experimenter to investigate the magnetic properties of the iron used in his experiments.

It is often desired to obtain the magnetic qualities of a certain kind of iron. In building dynamos and motors the iron to be used for the cores is always tested to ensure the best results. The following method is one of the simplest and is quite efficient:

A frame is made of cast iron, with the dimensions as shown in Fig. 1. A five-eighths inch hole is drilled in the top. The balancing apparatus is easily constructed, but care should be taken to see that points (A), (E), (X) and (C) are spaced at equal distances apart. A sample of the iron should be turned to one-half inch diameter and about 12 inches long, fitted with two small ears.

The coil is to be constructed next. It consists of 200 turns of No. 16 wire wound on a spool having a five-eighths inch hole through the center.

When these are completed the apparatus should be set up as shown in Fig. 2. A spring balance is fastened to the arm at (A), and the ears of the sample of iron are caught in (C). The iron sample passes through the hole in the top of the iron case and through the center of the coil and rests on the lower portion of the iron case. An ammeter is connected as shown.

First a current of one-half ampere is passed through the coil. Pull on spring scale until the sample is released from the influence of the coil. Note the reading on the spring scale at this point. If the spring scale is attached at (A), multiply the reading on its scale by 2 to get the true number of pounds. If the spring scale is fastened at (E), the pounds would then be correct.

Next allow one ampere to pass through the coil, and again pull the scale until the sample is released. (Note readings of pounds and amperes each time.) Proceed in this manner until a current of five amperes is reached. The magnetic density may then be calculated in the following manner:

First H must be found, by using the formula

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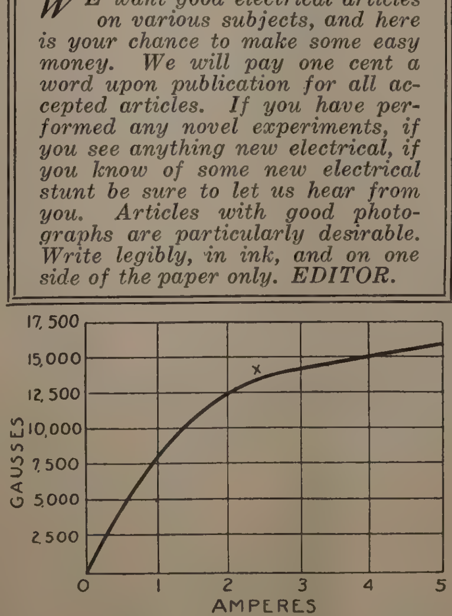
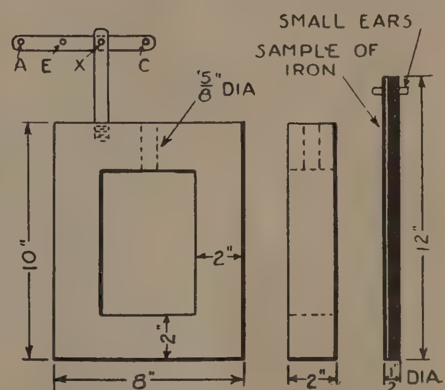


The graph illustrates the variation of magnetic density in an iron specimen with variations in the current through the electromagnet. Such graphs are at the basis of all dynamo design.



These details show the utter simplicity of the magnetic density tester. The frame recommended by the writer is of cast iron, but the core of a discarded closed-core transformer may be used with advantage.

$$H = \frac{4\pi NI}{10L}$$

$\pi = 3.1416$
N = No. of turns in coil
I = Current in amperes
L = Length of coil in *centimeters*

$$H = \frac{4 \times 3.1416 \times \text{No. of turns} \times \text{amps.}}{10 \times \text{length of coil in cms.}}$$

The magnetic density (B) equals

$$B = 1317\sqrt{\frac{W}{A}} + H$$

$$B = 1317\sqrt{\frac{\text{Pull in pounds}}{\text{Area of one end}}} + H$$

W = Pull in pounds
A = Area in *square inches* of *one* end of sample of iron

The values are calculated for each reading. In one sample of iron a curve of magnetic density was obtained similar to the one shown. Thus, when reading the "curve" to induce 10,000 lines in "sample" it would be necessary to use 200 × 1.5 amps. or 300 ampere turns.

In this particular sample of iron the maximum efficiency would be obtained by using 500 ampere turns, which would give 13,500 lines (point X on curve).

An Electrician's Christmas

By Esten Moen

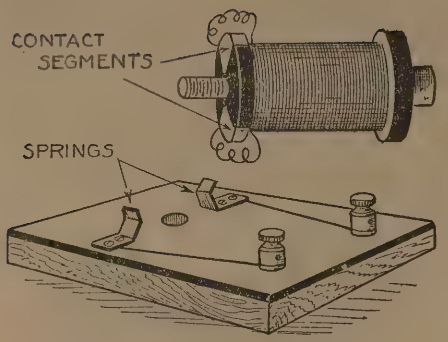


FIG. 1

An electromagnet adaptable to diverse experiments is here provided with a handy base from which it is readily detachable. By a twist of the magnet after it is inserted in the base it can be disconnected from the circuit.

'MEMBER the time when you was a kid—just pickin' up larnin' in 'lectricity—pickin' roses 'midst thorns? She shore was one hard-luck turn after another—but o' course THEM was the days! Now gone forever!

That little son of yours—or little brother, or early bird across the street—'jever spare him moments of sympathy? Now right here you can do that lad the finest help in the world—help him learn

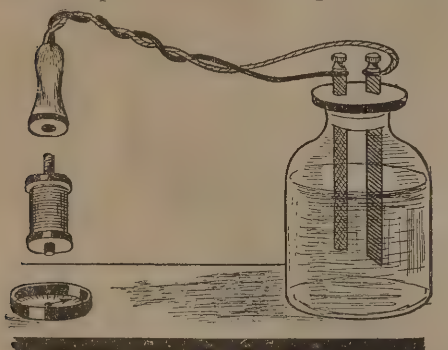


FIG. 2

Another application of Esten Moen's versatile electromagnet! A handle provided with flexible lamp cord makes a capital arrangement.

electricity! Yessir, you can do it; sure you can.

I'm trying the very same thing myself—there's a kid across the street here (in fact, there's a dozen—so I'd have to turn my lab into a factory to satisfy the demand, if)—so here: let's ALL get together and then mebbe we can have some peace in our lab (& heart) the rest o' th' year. C'mon ever-body, pull t'gether.

One thing a beginner must learn is "HOW is electricity made?" Materials needed:

One Mason fruit jar (quart size).
One ounces ammonium chloride.
One sheet zinc, size four by nine inches.
One carbon rod. (From an old dry cell, heated redhot and cooled).
Carbon powder and manganese dioxide. (Taken from an old dry cell.)
A small piece of cheesecloth.

That's the dope for a LaClanche "wet" dry cell.

There! That's hammered into his head—hey, I forgot—don't YOU make the cell; but rather give the parts to the kid and let HIM make it. Atta boy!

Now we'll attend to the coil end of the business. I s'pose you've all each made a million coils or so—well, some number 24 wire must be found; ya, an' some bolts—a stove bolt 3/16 inch by 1½ inches is dandy. Then from some rubber plate knocked off a storage battery jar cut some discs ¾ in in diameter, with a hole in the center to fit the bolt. This makes the ends of the solenoid form—the insulation around the bolt being one layer of tape.

Don't forget to tell the kid that he must wind evenly and tightly. I saw a kid unravel a perfect factory wound coil—then when HE rewound it she wouldn't work! Well, that's just the way—we bump into mystery everywhere, and it pays to keep your eyes open an' 'member ever'thin'.

Wasn't it a ticklish fool job to leave pigtails on a coil? Sure, 'sall right for radio coils—but f'rinstance, for doorbell and telegraph magnets? Listen an' I'll tell you a darn good secret—see Fig. 1. Well, the idea is given in Figs. 1 and 2—study them, please, 'cause I ain't got the eddication to pull extry words from ol' man Noah.

Then (heck, we're soon ready now. Gee, I wish we could study 'lectricity all day long, don't you?)—then, what to do with the magnet? Pick nails off the floor—play jackstraws, eh? or make a magnetic crane, or—well, we have to have a "jack" (we'll call the magnet a "plug," eh?) and a handle and some lampcord. You can see the dope in Fig. 2.

Last, of course, we gotta hev a buzzer-telegraph. Sure. So we'll need a board (base), a "jack" (see how handy? Now we don't have to wind another coil!), an' some more stuff shown in Fig. 3.

'Member your first buzzer? Iron contacts—after minute she quit buzzin'—the

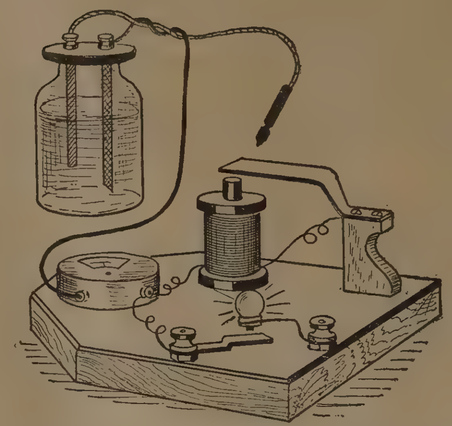


FIG. 3

The electromagnet again, now in the guise of an electric buzzer, offers another source of entertainment to the young experimenter.

iron burnt out. Well, you let the kid discover this for himself. Sure, don't tell him—he'll just rubber (gape) like a cow and feel insulted. Likewise unnecessary for me to say see Fig. 3.

Well, so long—hey, wait a minute, we gotta have a motor—and a light! 'Member how hard it was for you to understand it takes two wires to light a lamp?

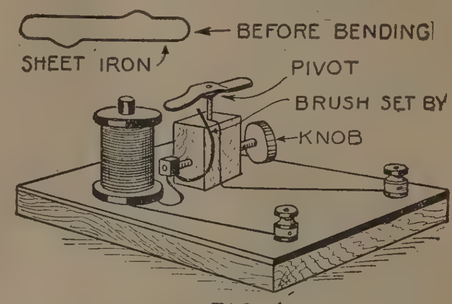


FIG. 4

Here is a fascinating example of the electric motor, improvised from pieces of sheet iron, wood, wire and the detachable electromagnet used throughout these experiments.

Well, a motor's purty hard to make. Shucks. Well, don't give up the ship, boys—they's a peacherino all dolled up in Fig. 4. Some bimbolina, hey?

Gosh, I hate to quit playin' with 'lectricity, don't you? Shucks, well, ma has some cookies for us. Le's go. S'long, fellers. MERRY XMAS. HAPPY NEW YEAR.

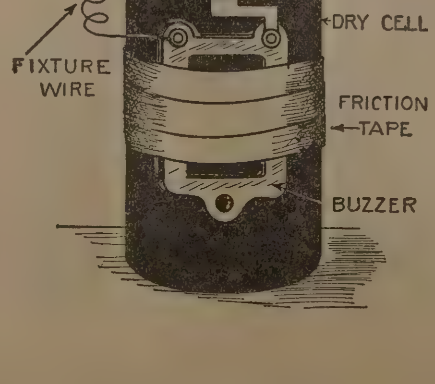
Christmas Tree Lamp Tester

A VERY serviceable Christmas tree light tester may be made with one dry cell, one buzzer, and several scraps of copper.

The buzzer is fastened to the side of the dry cell with friction tape. The outside binding post of the battery is connected directly to one side of the buzzer with a short piece of fixture wire.

A strip of copper soldered to the center binding post of the battery comes within an eighth of an inch of a similar strip fastened to the other side of the buzzer. If the buzzer works when the lamp is placed across the copper contacts the filament is good.

The apparatus is not a plaything but of size and corresponding efficiency to make it thoroughly practical. The voltage of a single cell would not show by its effect on a lamp, but enough current will go through the circuit to operate the buzzer.



A most convenient appliance to prevent disappointment in the illumination of the Christmas tree. It does not ensure good lamps, but it tells if they are out of order or disconnected.

When testing out a tree circuit the lamps will not have to be watched, the slight noise of the buzzer tells the whole story. The tree may even be tried out in the presence of guests if the buzzer is not too vigorous in its action.

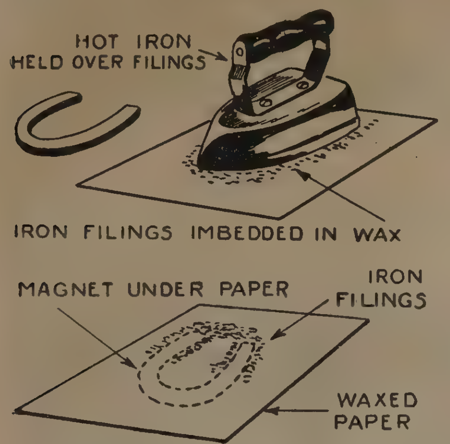
Contributed by WALTER NORRIS.

Preserving Magnetic Curves

By Earle R. Caley, B.Sc.

THE usual method of recording the curves formed by iron filings in the vicinity of a magnet is to dust iron filings over a piece of blueprint paper and after a few minutes' exposure to strong light, to develop and fix the picture so formed, by immersion in water.

While this is a very convenient and satisfactory method of showing roughly the paths taken by magnetic lines of force in picture form, yet it is sometimes desirable to preserve the actual iron filing figures themselves. The blueprint method, furthermore, does not show the curves in relief, and therefore does not faithfully



A delicate and transitory experiment is here made permanent. The iron filings disposed around a permanent magnet are made to absorb by capillarity the warm wax covering the paper upon which the filings are spread, fixing them permanently.

record the large arched figures caused by iron filings in the vicinity of a powerful magnet. Several methods for preserving the original iron filing curves are given in the following paragraphs.

The first method is well adapted to preserving the curves formed by rather weak magnets in which the figures formed are not in marked relief. A piece of stiff paper such as manila drawing paper is thoroughly waxed by placing upon it shavings of beeswax or paraffin wax and ironing the wax in by means of a warm iron. This prepared paper, when cool, is then placed over the magnet or magnets, whose curves are being recorded, and fine iron filings are dusted on and the paper is tapped gently to produce the magnetic curves. When satisfactory curves have been formed a very hot iron is held above the filings, as close as may be without touching them or the paper, and the wax on melting rises by capillary attraction between the filings. On removing the iron the wax solidifies and the magnetic figures are thus permanently fixed upon the paper. It may be advisable to remove the magnet before applying the hot iron, as the pressure of the iron in the magnetic field may shift the curves.

Where the curves are formed by a strong magnet and are somewhat in relief they may also be preserved in wax by a similar method. A piece of stiff cardboard, or better still, a small piece of ordinary window glass, is selected and coated with a fairly heavy layer of paraffin wax. The glass is coated by carefully warming it and allowing the wax to run on while the cardboard is heated with a hot iron. The prepared cardboard or glass is then placed upon the poles of the magnet whose curves are to be recorded and the figure built up by carefully dusting on a quantity of iron filings. When this figure has reached the desired dimensions a quantity of fine shavings of paraffin wax is scraped over the curves and dropped thereon. A very hot iron is then held near the figure. As before, the molten wax runs between the iron filings and on cooling the figure is permanently fixed.

Another method of preserving curves in wax is adapted to recording the entire curve surrounding the pole of a magnet. The foregoing methods are only applicable to recording curves in a single plane.

COLD VACUUM TUBES

At the present time we must heat the filament in our vacuum tubes in order to operate them. In the very near future it is likely that we will use cold tubes. Interesting speculation is given on this in a comprehensive article by J. H. T. Roberts in the December issue. READ ALL ABOUT IT.

Articles to Appear in the December Issue of Radio News

The Behavior of Radio Waves and the Heaviside Layer
By Sir Oliver Lodge

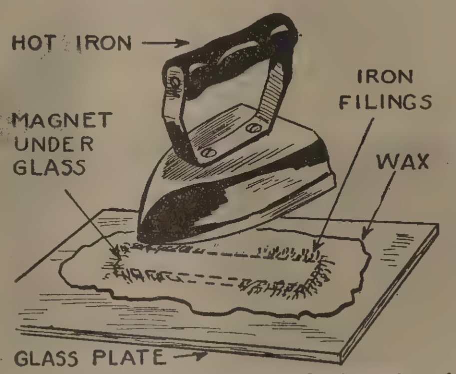
A Radio Controlled Railroad Block System
By Howard S. Pyle

Fake Radio Doctors
By Hugo Gernsback

A New Very Short Wave Oscillator
By Ross Gunn

A Short Wave Super-Heterodyne
By J. L. Cassell

The Cold Tube of the Future
By J. H. T. Roberts

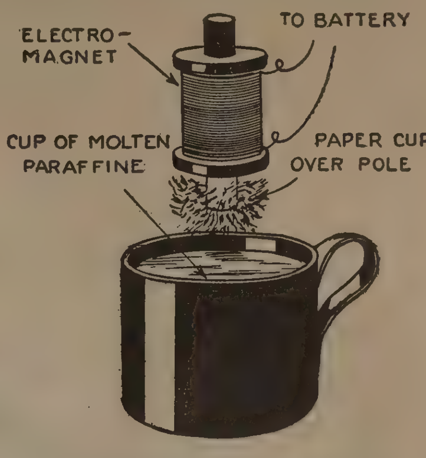


Another method of retaining the formation of iron filings is illustrated above. By the use of a heavier layer of wax upon a plate of glass and a stronger magnet, the field is better shown.

The curves for the method next to be described are best formed by an electro bar magnet. A small cup made from cardboard or non-magnetic sheet metal is needed in this method to slip over the pole of the magnet and form the curves on. One can be readily made by gluing a round disc of cardboard in the end of a short length of brass tubing of a diameter slightly greater than that of the magnet pole. This cup is then slipped on the magnet pole, the pole dipped into a pile of iron filings and the excess filings shaken off to properly form the figure. When a satisfactory figure has been obtained it is slowly and carefully lowered into a cup of molten paraffin and then carefully removed again. On cooling, the cup and magnetic figure may be slipped off the magnet pole.

Care must be taken that the current through the magnet remains constant until the figure has solidified. The above method may be also applied, using some sort of rapid drying spirit varnish such as collodion or ordinary alcoholic solution of shellac. This is more permanent in warm climates. In using this latter medium, however, the current must remain on much longer during the drying period.

A useful method of preserving these curves for instructional purposes or for cabinets of physical specimens, is to employ small permanent horseshoe or bar magnets and by the last method preserve



The field around the end of a bar magnet can be shown in striking relief, by immersing the cluster of iron filings formed on a card-board cylindrical case placed on the end of the magnet, in melted wax; after withdrawal and cooling it is permanent.

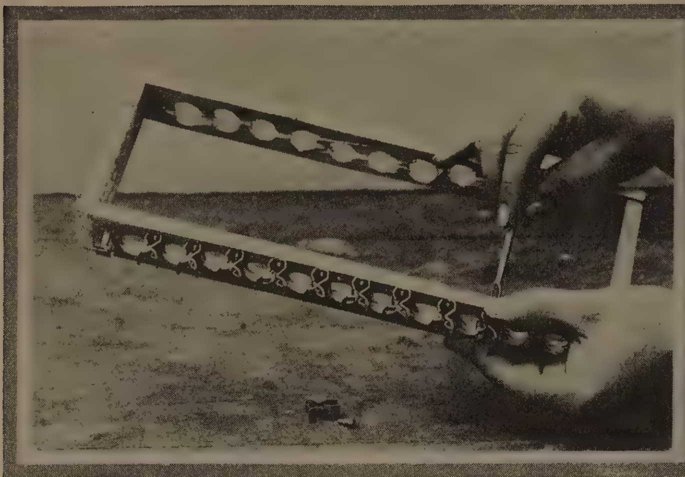
the figures in place upon the magnets. These small magnets dipped into iron filings and then carefully lowered in molten paraffin or diluted orange shellac by suspending them from a thread to be removed and left to solidify form very interesting specimens for the electrical cabinet or lecture table.

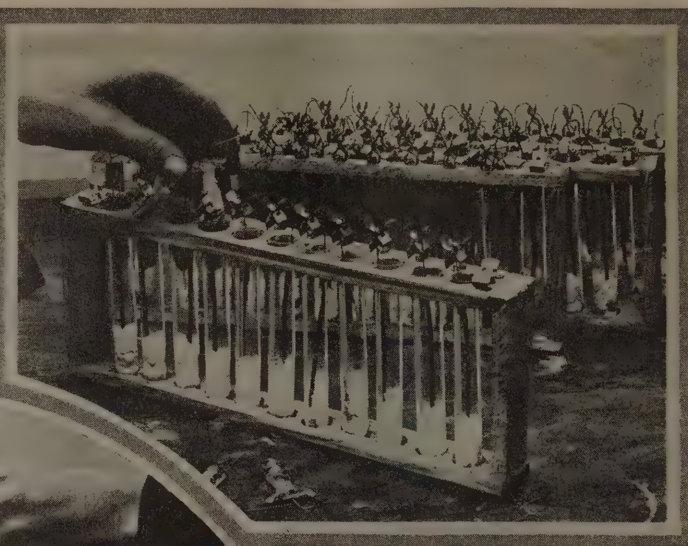
Referring to the method of capping the pole of a magnet for the exhibition of lines of force to be shown by the disposition of fine filings, if a horseshoe magnet or better yet a double pole electromagnet is used, an arch of filings will be formed across from pole to pole, forming a little bridge. These may also be fixed with paraffin and quite interesting exhibits may be thus prepared, which, of course, would be somewhat fragile. If the caps are well made the little bridge can be lifted from the magnet.

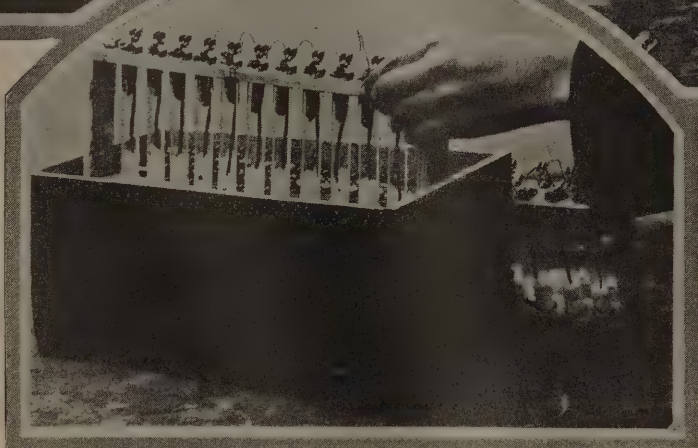
While on this subject, there is an experiment which can be performed with fine filings and a magnet which is so good that it is a pity not to give it here. The filings attracted and retained by a magnet, if fine enough, may be started into incandescence by means of a gas burner producing their oxidation. It is better yet to use iron reduced by hydrogen. This is prepared by acting with hydrogen gas on iron oxide maintained in a tube at a high temperature; this produces pure iron in the highest practical state of division and when retained by a magnet pole and touched to the outside zone of a Bunsen burner flame, it will sparkle as it burns like tinder. As it does this it forms magnetic oxide of iron and continues adhering to the pole, but not showing the curves as nicely as the metallic filings do. It would seem even to be a good way of igniting iron in oxygen gas, the ignition to be started by an incandescent wire imbedded in the filings.

Making a Radio "B" Battery

By Dr. E. Bade







(Above) Working on the frame which is to hold ten tubes, constituting one of the sections of a radio B battery.

(Below) Putting the copper sulphate crystals into the tube after the introduction of the copper wire electrode. These crystals dissolve little by little and are expended; new copper sulphate is needed at intervals. The upper solution must sometimes be withdrawn and water substituted.

(Above) Cutting up the strip for the zinc electrodes which are next to be introduced. Now that the copper electrodes and the copper sulphate are in the tube, notice the clips on top.

(Below) Putting in the zinc elements. These are very short, in order to keep them well above the copper sulphate solution.

(Left) Putting the complete section into the battery box which may hold eight or ten racks of ten tubes each.

FOR radio work those types of batteries are preferred which give a constant voltage and amperage. All other types, and they are many, will not give best results for the voltage produced soon diminishes in value. The Daniell cell is constant.

For the battery containers or jars test tubes are taken; the larger these are, the better will the results and the longer will the life of the battery be. Those which are six inches long and three-quarters of an inch in diameter are the smallest size that can be used successfully. Make a set of frames or racks for these test tubes, using 11 tubes to a rack. Each tube will give a little less than one volt so each frame may be taken as good for 10 volts. At each end of the rack there is a flat battery clip, and between each two holes an upright battery clip.

Prepare next for each tube a rubber covered wire as follows: Cut off a length about four inches longer than the tube. Expose an inch on the top so that it can be held in connection by the clip. The other end is also exposed, taking off about three inches of insulation and winding this into a spiral to fit the bottom of the tube tightly; this is the negative electrode. Only rubber covered wire can be used.

When all the negative elements are introduced, fill the tubes one-third to one-quarter full of copper sulphate crystals.

Now it is time to make the positive elements. Here either heavy strips of zinc which enter the tube about one-third down from its top, or specially formed elements are used. The former are provided with a wire which can either be soldered in place or attached with a bolt and nut. The latter type are made by melting the zinc over a Bunsen flame and pouring the molten mass into a mould made of refractory substance like well dried clay (not mud or loam) which has been given the desired shape. Just after the metal is poured, a small piece of copper wire provided with a small hook, is inserted near the top of the molten mass. When cold, this wire will form the negative terminal of the cell.

Insert these zinc elements into the test tubes after the copper sulphate crystals are introduced. Then attach the wires to the clips. Begin with the end. Fasten the positive or long copper wire to the end clip. The zinc element of the same cell is attached to the upright clip on the side of the frame. To this same post attach the negative element of the next cell. The zinc of this second cell goes to the second upright which also receives the negative of the third cell. In this way the set is wired in series until the final wire, which is the negative, goes to the flat clip. This set will give approximately 10 volts. We will make five such sets and the terminals of each set are brought

to the front of the box by wires where the voltages desired can be taken off in steps of ten each. This is effected by wires leading from the various terminals to the box, the entire battery being connected in series. Connect each set of batteries in series. Then, taking the first set take a lead from the negative or zinc pole to a binding post outside of the box. Plainly mark this pole with a minus sign. The plus pole receives two connecting wires. One wire leads to a binding post marked 10 + outside of the box, the other wire leads to the second set of batteries and connects the positive of set A with the negative of set B. The positive of set B is again brought to another binding post outside of the box marked 20 +. The negative of set B goes, as has been said, to the positive of set A. The positive of set B goes to the negative of set C, the positive of set C goes to the negative of set D and so on, and the positive of each set connects with a binding post outside of the box where the battery can be easily tapped for any voltage.

This battery is especially valuable for the detector circuit of any set. In the amplifying circuit it will not be of special value, but if it is used in the amplifying circuit, then use a standard dry cell B battery for the detector circuit. Under this latter condition very satisfactory results can be obtained.

When the battery is ready for use fill it with a dilute solution of zinc sulphate in water using about a teaspoon for each glass of water, or use dilute sulphuric acid, adding one part of the acid in ten parts of water. If acid is used the zinc should be amalgamated. Fill the test tubes to within three-quarters of an inch of the top; over this pour a layer of oil to prevent evaporation. As soon as the battery is filled, it is ready for use. As this battery is a closed circuit battery, it will operate best if used at least four or five hours each day; if left in open circuit, that is if not used for a number of days, the battery will spoil and will have to be refilled. If crystals make their appearance on the zinc, clean the tube by pouring out the water and renewing the solution. If all the copper sulphate is used up, renew this also. One filling of copper sulphate should last from three to five months. One filling of the test tubes mentioned, lasts about four months, but if the set is used during afternoon and night, then it will last only three months.

Don't depend upon a meter to give you the condition of this battery. The ordinary ammeter and voltmeter cannot be relied upon to give accurate readings. The voltage of each cell is slightly below one volt, while the amperage is very low, requiring a very delicate milliammeter. The best test for the condition of the battery is visual examination. A brown deposit on the zinc element does not materially depreciate its life, still it is best to remove this deposit of copper. Never shake the battery, let it stand on one spot. Remember this is a gravity cell and the copper sulphate should remain below the zinc element if the battery is to work efficiently. If the blue color of the copper sulphate solution rises more than half way to the zinc, some of the colorless solution should be pipetted off and be replaced by water. Do not leave the battery too long on open circuit. Give it a "run" now and then to prevent the copper sulphate solution from reaching the zinc.

Electro-Magnetic Induction

By Harold Jackson

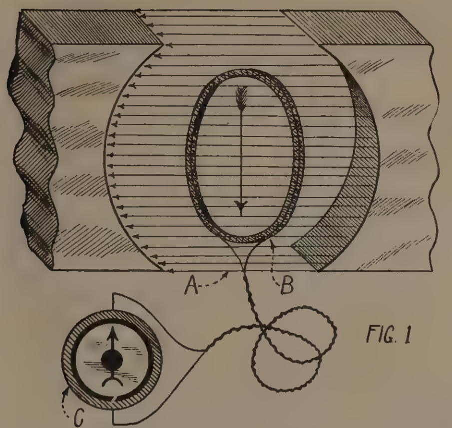


Diagram explaining zero potential induction. A coil of wire cuts a field of force without result.

ALL dynamos of whatever form are based upon the phenomenon discovered by Faraday known as "induction." This word has several meanings as applied to electricity. Its general meaning is the effect produced in bodies by the influence of other electrified bodies having no electrical connection between them.

If a body charged with electricity be placed near an uncharged body the charged body will "induce" charges in the uncharged body; this is known as electrostatic induction. A magnet will induce magnetism in neighboring bodies of iron by the process called "magnetic induction."

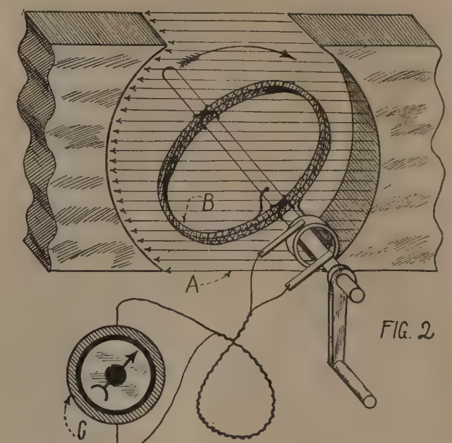
The electric current induced in a conductor by moving it in a magnetic field so as to cut the magnetic lines of force is caused by the phenomenon of "Electro-Magnetic Induction." If the conductor is in the form of a coil, the movement of this coil must be such that the number of lines of force passing through it will be altered; for example, if the coil of wire is passed through a uniform magnetic field in a straight line as shown in Figure 1, at (B) no current will be induced in it as indicated by the galvanometer (C), which is connected between the ends of the coil.

The reason for this is that the coil in a straight down movement leaves as many lines of force behind as it gains in movement. In other words, the number of lines of force embraced by the coil is not altered in its movement; such condition of change is necessary for the induction of electric currents in the coil. If the same coil be secured to a shaft provided with a crank as shown in Figure 2, so that it can be rotated, as indicated by the arrow, the number of lines of force embraced by the coil will be altered and an electric current will be induced in the coil, which will be indicated by the deflection of the galvanometer needle.

In Figure 2, starting with the coil in a perpendicular position, the first quarter of a revolution will raise the pressure in the coil from minimum to maximum pressure, the next quarter turn the pressure will die down to minimum again. The same process will occur in the remaining half revolution of the coil. Therefore there will be two electric impulses induced in the coil for every revolution it makes in the magnetic field. For one-half of the cycle the induced current in the coil will flow in one direction, and, in the opposite direction during the second half. Alternating current will be induced in the coil as it is revolved in the magnetic field, cutting the lines of force that thread from the north to the south pole of the field magnet.

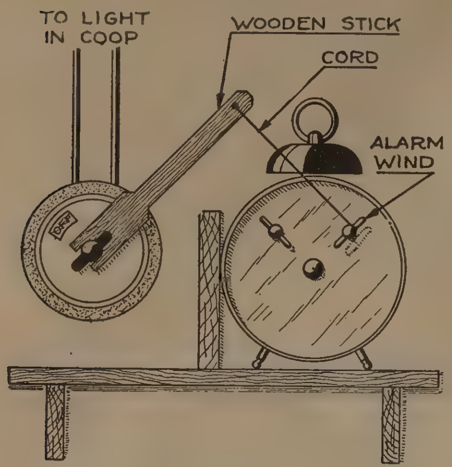
The rate of increase or decrease in the number of lines of force embraced by the coil governs the electro-motive force induced therein. The e.m.f. is increased with the increase in number of turns in the coil, also by the increase in speed at which the coil is rotated.

The direction of the induced current is always such that its magnetic field opposes the motion which produces it.



Here lines of force are so cut that the number traversing the coil changes, thereby generating electric potential as shown on the voltmeter.

Alarm Clock Chicken-Feeding Device



Industrial efficiency in the chicken house is assured by this ingenious device which by the aid of an ordinary alarm clock turns on the electric lights in the coop at a predetermined time, thus inducing the chickens to feed.

IN the illustration is depicted a novel means of making chickens begin scratching about 4 o'clock in the morning.

The chickens are fed at night after roosting, the alarm clock is set at the hour desired, and in the early morning electric lights are automatically switched on, inducing chickens to start feeding.

The switch is a common snap switch, with a hard rubber knob. The stick is cut to fit the switch knob loosely. The cord is fastened to the alarm-winding key, and when the alarm rings the revolving alarm-key winds in the cord, thereby turning the switch. The wooden brace holds the clock firm against the tension of the switch. The alarm bell can be eliminated for the sake of quietness.

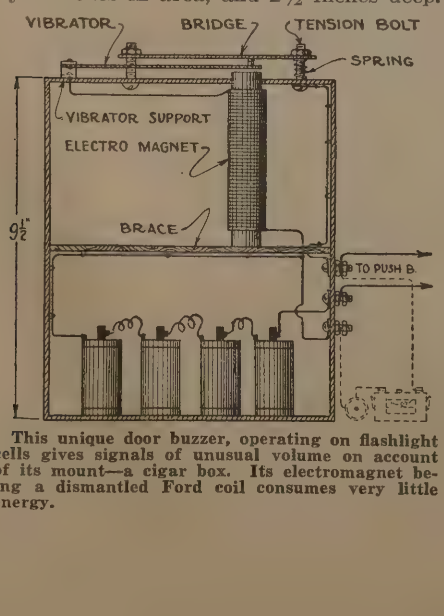
This idea has been used very successfully, especially during the dark winter months.

Contributed by LAWRENCE TELLIER.

Flashlight Door Buzzer

By GEORGE W. ROGERS

THIS buzzer may be mounted on a cigar box, which may be about 9½ inches by 6 inches in area, and 2½ inches deep.



This unique door buzzer, operating on flashlight cells gives signals of unusual volume on account of its mount—a cigar box. Its electromagnet being a dismantled Ford coil consumes very little energy.

A Ford coil unit, doorbell push-button, a strip of wood 5¾ inches long, ½ inch thick and 1 inch wide, a short piece of bell wire and a battery are required.

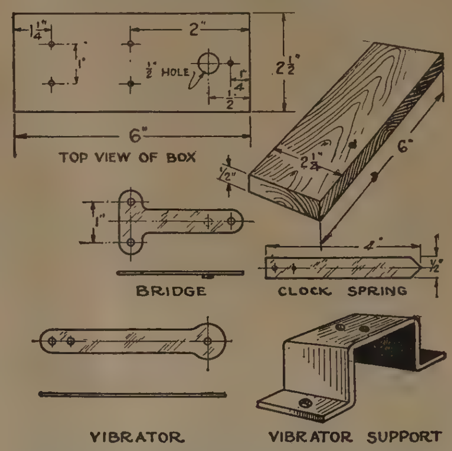
Three different kinds of battery may be used, as follows: Four-cell unit flashlight battery, connected in series; hot-shot battery, or 6-volt wet cell battery. The wet cell battery is to be recommended, as the charge will last for nearly the entire life of the battery if the buzzer is adjusted properly and the battery taken care of.

The first step is to secure the cigar box. Stand this box on end with the open side facing you. In the upper end of the box drill a hole as shown in Fig. 2. Now dismantle the Ford coil unit; remove the secondary coil wire from the coil, leaving the primary winding. Be careful to notice how the vibrator of the bridge is arranged. Fig. 2 shows the coil unit dismantled, with the secondary windings removed.

The original vibrator should not be used, as it is too short. As a substitute a piece of clock spring 4 inches long, ½ inch wide should be cut and two holes drilled in one end, as in the original vibrator, should be pointed and turned up ⅛ inch. After the bridge and vibrator have been assembled, a piece of wood 6 inches long, ½ inch thick, 2¼ inches wide is made, and a ½-inch hole drilled ½ inch from one end. One end of the electromagnet is placed in the ½-inch hole in the top of the box and the brace shown in diagram, Fig. 3, should be nailed in place, allowing the upper end of the magnet to project through the top of the box ½ inch or ¼ inch.

Connect the magnet, vibrator and bridge as shown in diagram, Fig. 3. Three terminals are placed on the right side of the box; two will do if the maker wishes to use other batteries than the flashlight battery. The frequency of the buzzer may be regulated by the tension burr on top of the buzzer as shown in Fig. 3.

The dotted lines leading from the buzzer show how to connect up for wet battery or dry cells. The straight lines show how to connect up for flashlight battery. The noise that can be produced by this buzzer is surprising, in view of the small amount of current required. The writer has a 6-volt wet cell battery which is sometimes used to operate a flashlight bulb, to light a closet, and this battery will operate the buzzer without any trouble.



Principal details of the flashlight-cell door buzzer; all readily constructed even by the least skilful experimenter. The parts besides the cigar-box wood are odd pieces of sheet metal.

Simple Oudin Coil

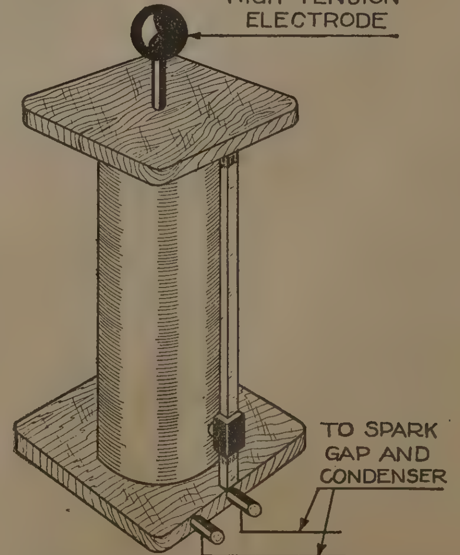
MANY electrical "bugs" would like to experiment with high frequency currents, but do not wish to undertake the construction of an elaborate Tesla or Oudin coil. They will find their problem easy to solve if they have a one or two slide tuning coil.

By connecting the coil as shown in the diagram and providing the other necessary apparatus a very effective Oudin coil will be the result.

It will be seen that the primary circuit of the coil consists of five or six turns of wire included between one end of the tuning coil and one slider. The other end of the coil provides the high tension terminal of the secondary circuit.

If the coil is provided with two sliders it will be possible to vary the inductance of both primary and secondary circuits.

Contributed by CHAS. D. SAVAGE.

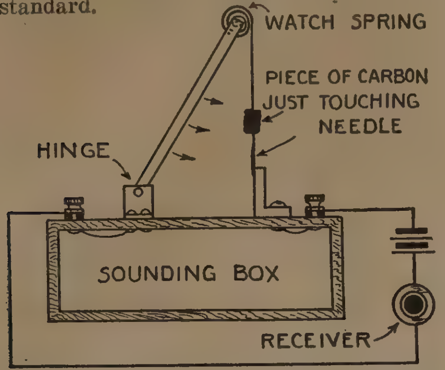


A simple and effective form of that endless source of electrical experiments, the Oudin coil, is shown above. It is constructed on the core of an old "tuning coil."

Needle Microphone

FIRST it is necessary to construct the sounding box, which should be made of wood. The size may be as desired, as it is not of importance, but should not be too large.

Erect a small standard of steel near one end of the box, as shown in the illustrations. By means of solder fasten a large steel needle, point upward, to the standard.



This microphone for the amateur experimenter has an extremely sensitive contact and will give remarkable results.

At the foot of the standard place a binding post and another at the other end of the box. Procure a strong steel watch spring and attach it to a light bar of steel. Fasten this steel bar to the sound box with a lock screw.

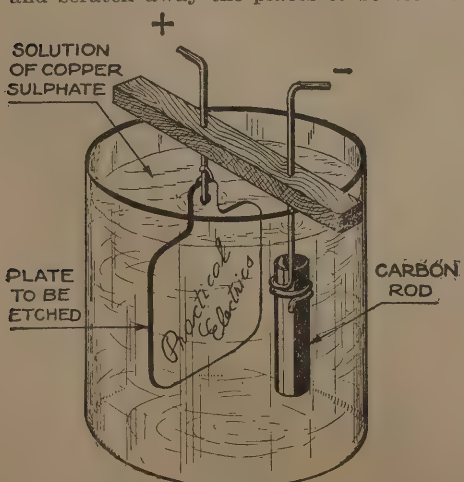
To the end of the watch spring, which hangs loose, fasten a piece of carbon so that it will just touch the point of the needle projecting up from the standard. If you happen to possess an old telephone receiver there will be no forther trouble in obtaining the necessary materials to go ahead with the construction.

A good battery and some wire are the only remaining necessities, not considering the receivers, which are no doubt obtainable around the workshop. Wire from the battery to the receiver, then to the binding post on one side of the sounding box. From the binding post string wire to the foot of the steel rod. Another wire is connected to the remaining binding post near the upright on the sounding box. Take the wire from the binding post to the base of the upright. Then hold the receiver to the ear and listen.

Contributed by WALTER BROLIN.

Electric Etching

TO etch by electricity cover the plate to be etched with paraffin or bees-wax and scratch away the places to be etched



A simple rigging for etching by the electrolytic process; an outside source of electricity is required.

as usual. Then place the plate to be etched in a solution of copper sulphate, together with a battery carbon; attach the positive of a battery to the plate to be etched and the negative to the carbon.

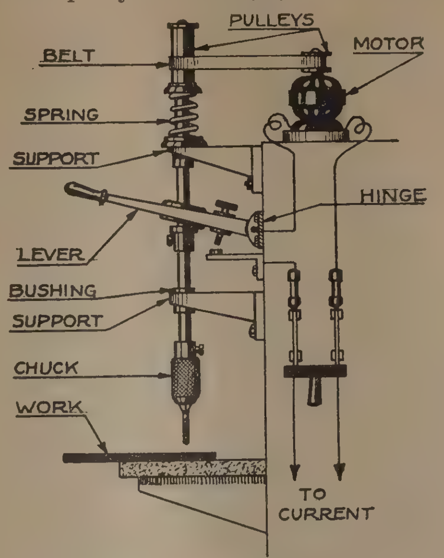
After a few hours the plate will be etched sufficiently and may be removed from the solution. The more cells used the quicker it will get done. Copper, zinc, iron, etc., may be etched in this manner.

Contributed by ARTHUR A. BLUMENFELD.

Electric Drill

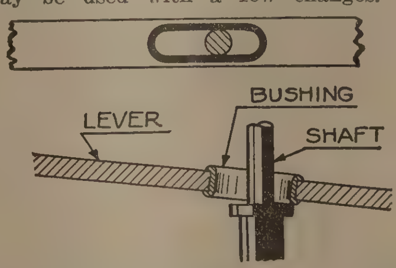
A SIMPLE drill for use in the small workshop or garage may be made quite cheaply by utilizing odd parts which are usually found lying around. The drill described has an automatic switch which is turned on every time the lever is lowered to bring the drill-point to its work, though this switch is not necessary and may be omitted if desired.

The drill is mounted on a wall or other vertical support. The first part to procure is the shaft, which should preferably be of steel. Two iron supports are arranged as shown to hold the shaft. These should have snug-fitting bushings so there will be very little "play" in the shaft. On the top part of the shaft is arranged a long pulley as shown, which had a belt running to the pulley on the motor.



An electric drill, readily constructed from odd parts. The motor is automatically started when the drill point is lowered to its work, the handle, when pulled down, closing the circuit.

The motor shown in the illustration is mounted vertically, though almost any type may be used with a few changes. A



A section showing the arrangement of the lever for the vertical motion of the drill. Notice the oblong hole for the shaft.

fairly heavy spring is mounted on the shaft between the pulley and the top support, so the shaft will return to its normal position each time. The pulley and part which holds the spring to the shaft should be very well attached, so it will not come off with the pressure applied.

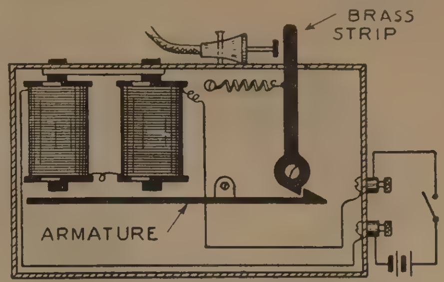
On the lower end of the shaft is attached a chuck for holding the drills. The most difficult part is the lever for lowering the shaft to drill the holes. This lever arm is on a hinge. In the lever where the shaft passes through is a slot which is fitted with a bushing also. On the shaft directly under the lever is a piece fitted on the shaft as shown so the lever pressing down on it causes the drill to lower to the work. This part should always be kept well oiled to prevent wear. The contact part is made on the lever as shown, a large adjusting screw and piece of spring brass being used. The contacts should be of quite heavy metal.

Contributed by EVERMONT FISEL.

Photography of Birds and Animals

By GEORGE F. FAUVER

THE kodak shutter release illustrated is very useful for making snapshots of wild birds and animals. A portrait attachment can be used to get "close-ups"



This magnetic release for kodak shutters enables the photographer to take snapshots of bird and animal life.

with this instrument, which would otherwise be impossible to obtain.

The release is constructed thus: The magnets of a telegraph sounder are mounted as shown in a wooden box $5 \times 3 \times 2$ inches. An armature is made with a detent on its end which engages a corresponding notch in a brass strip, which has a spring to give pressure to the shutter release.

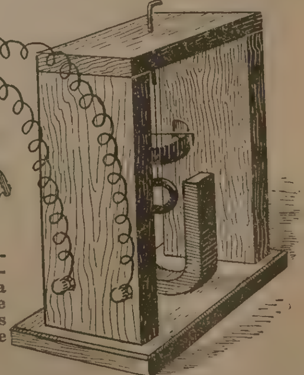
The armature, spring and hammer-like strip are fastened to the bottom of the box with small wood screws; the coils fasten with screws through the side of the box and the distance of armature from the poles of the magnet may be adjusted by placing washers between the top end of coils and box. The shutter release of the kodak is held in place by two flat head wood screws placed a proper distance apart in the side of the box.

Three dry cell batteries, a push button or auto light switch and lamp cord of suitable length, complete the necessary equipment.

Simple Thermocouple

By ESTEN MOEN

HERE'S a stunt I ran across—it's so good I'm passing it on. For a thermocouple you invariably use a junction of two different metals. But the same metal can be used alone. See the illustration—some heavy copper wire is twisted as shown—if too much it is "short circuited."

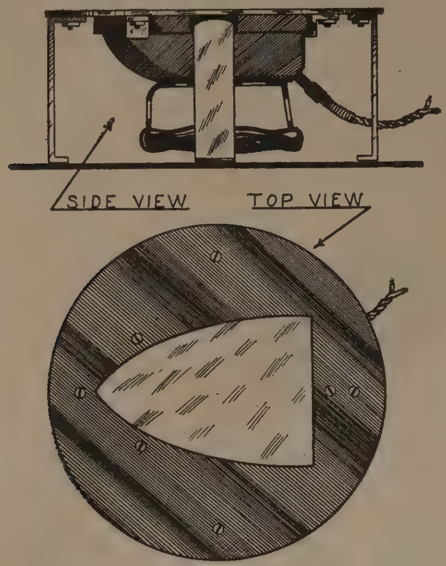


Here is an interesting experiment with a thermocouple whose elements are of the same metal.

The two terminals at the top connect to a sensitive galvanometer — the lower ones are free, but a piece of cloth or thread is wrapped around each. Then carbon disulphide, gasoline, naphtha or ice cold water is poured on one (the object being to cool it). Boiling hot water is poured on the other cloth.

Electric Flatiron Stove

THE illustration shows how to make a very satisfactory small electric stove. The heat is supplied by an ordinary electric flatiron which is mounted, as shown,



Getting the most out of your flatiron. Here is a way to use it for an electric stove.

in a simple stand in an inverted position. The top of the stove consists of a disc of sheet iron about nine inches in diameter. In the center of this disc cut a hole that exactly fits the face or bottom of the iron. Three strap-iron clips, applied as shown, hold the iron in place so that the bottom of the iron is flush with the top of the disc.

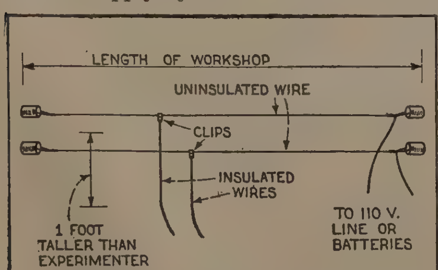
The stove is supported by four strap iron legs which are bolted near the outside edge of the disc. These bolts, as well as those used in fastening the clips, should be flat-headed stove bolts, with holes for them countersunk in the disc, so as to leave the top smooth. The legs should be just long enough to prevent the handle of the iron striking the table.

The iron is easily put in or taken out of the stove. The hole into which it fits should be a rather loose fit to facilitate this operation. The connection plug is removed while making the change.

Contributed by HAROLD JACKSON.

Overhead Current System for the Laboratory

ONE of the problems of the laboratory is the distribution of the current source to different devices. The illustration shows how any experimenter's laboratory can be bettered with an improved current supply system.



A sort of two or three trolley wire circuit for the laboratory; currents can be taken off as desired.

The current, be it battery or the house main, can be led through two bare wires spaced about a foot from each other, running across the laboratory and at least a foot above the experimenter's head. The bare wires should be fastened to the walls with porcelain insulators and the battery current or 110-volt system connected to the bare wires at each end, one side being connected to one wire and the other side of the current system connected to the other wire.

The current is taken off these two parallel wires by means of flexible insulated wires with spring clips soldered at their ends. These wires can be led to any instrument no matter where it is located upon the laboratory or shop bench.

A third wire can be strung between the two. One end of this wire can be connected with one side of a lamp, the other side of the lamp can be connected with any one of the two wires already in position, as is shown. Now by taking off by means of the wires with spring clips, from this added center wire, and the side wire, a source of current with a lamp in series with it, whether it be 6 or 110 volts, can be obtained.

Contributed by RAYMOND B. WAILES.

Dr. Jekyll and Mr. Hyde

By ESTEN MOEN

IT'S a pleasure, fellows, to play with the apparatus I told you about in the August and September issues of "P. E." There is no end to the great variety of experiments possible with such instruments.

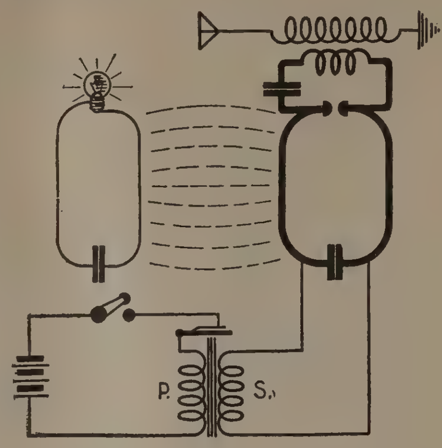
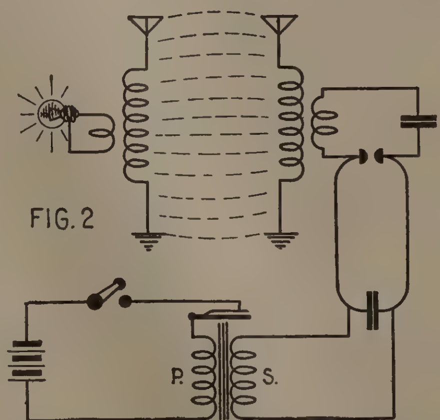


FIG. 1



Further stunts with the wireless transmission of power; humorous presentation of the subject by Mr. Moen, who advocates simplicity in experiments.

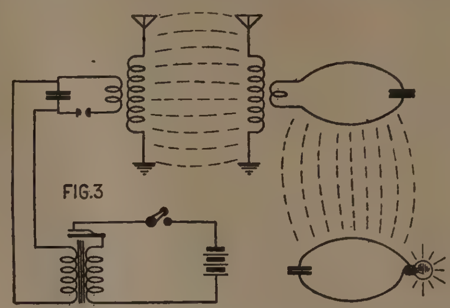
Just lately I ran across some more interesting "stunts" that can be easily done.

For example, there is the special oscillator connection of Figs. 1 and 2. You will notice that two different waves entirely are being emitted, viz., electromagnetic and electrostatic. In Fig. 1 the electromagnetic is shown operating a lamp, and in Fig. 2 the electro-static.

Another stunt illustrated in Fig. 3 is to convert electro-static vibrations into electromagnetic. Thus we see that in the final analysis "Dr. Jekyll" is the same as "Mr. Hyde."

Then, too, you can play the Dickens with the loop. Suppose your oscillator loop is round, but your receiving loop is square—ha! ha! no juice will be received; but let both loops be round (or square)—then she sure works!

Or else, you can twist your loops into queer geometrical shapes (triangles, squares, rectangles, etc.) and the fact will be seen that all loops must be similar!



Here is a way of converting electromagnetic into electro-static vibrations, according to our author.

Just one more stunt I should have written up long ago. It's shown in the photograph. Notice, transmitting and receiving Tesla coils are connected with short wires. Now the receiving lamp incandesces, without the addition of resonator coils, but add two resonator coils as shown and the light goes out! That's Dr. Jekyll.

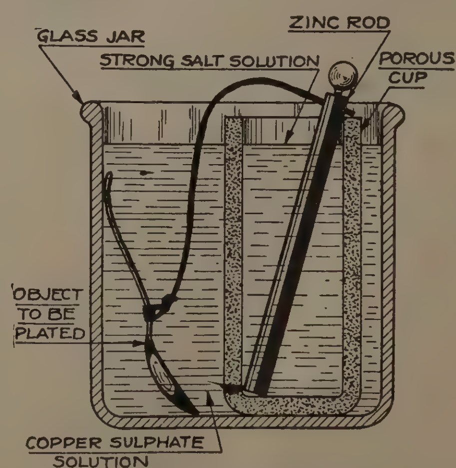
But have patience and we'll produce Mr. Hyde. Lengthen the wires, between oscillator and receiver, to about ten feet (and four inches apart); now without the resonator coils the lamp is out. But add the two resonator coils, equally spaced, and the lamp lights! That's Mr. Hyde!

Well, so long, fellers, till we meet again—but, what you say, ain't a Tesla coil *some* pal in a boy's studio or bedroom? She sure is!

Simplified Copper-Plating

HERE is a simplified method of copper-plating. Place a porous cup containing a strong salt solution into a large glass jar containing a strong copper sulphate solution so that the levels of both solutions are the same, and then put a zinc rod into the porous cup.

To copperplate anything, simply attach a wire from the zinc rod to the object to be plated and place the object in the copper sulphate solution. By this method the copper is plated out slowly, but it



An easy copper plating experiment that may have useful applications about the laboratory and in the household. The use of a porous cup is its characteristic feature.

gives a good hard deposit. It will work better after it has been in use for some time.

Contributed by ARTHUR A. BLUMENFELD.

Awards in the $50 Special Prize Contest
For Junior Electricians and Electrical Engineers

First Prize,	Second Prize,	Third Prize,
Harry H. Farb,	Roscoe Betts,	A. Hymus,
163 Peshine Ave., Newark, N. J.	Box 4, Arcadia, Neb.	29 Lynd Ave., Toronto, Canada.

First Honorable Mention—Lester Schultz, Jr., 58 Van Reipen Ave., Jersey City, N. J.
Second Honorable Mention—George W. Rogers, R-3 Box 19 C, Tacoma, Wash.

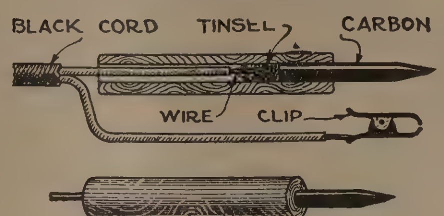
First Prize
Electric Soldering Iron
By Harry H. Farb

MANY experimenters would like to own an electric soldering iron, but find the cost prohibitive.

I am about to describe a simple but excellent soldering iron which may be supplied with current from a storage battery. The implement is also very light and is very desirable because one may solder connections in his radio set from his storage "A" battery without the trouble of connecting it to the house lighting circuit with plugs and long wires.

To make this soldering iron you must have a wooden bundle carrier such as are fastened to packages at the chain grocery stores, a carbon from a flashlight battery, about three feet of flexible cord (double) and three battery clips.

First file or sandpaper down one end of the battery carbon to an edge like that of a screwdriver, the brass cap having been removed; force the other end into the hole of the wooden handle, after having removed the wire. The carbon should be inserted into the wood a distance of about half an inch. Then take some tinsel from some Christmas tree decoration and push it in the opposite end of the wooden handle to press against the carbon. Strip about one-half inch of one end of one of the wires in the flexible cord and push it in the handle against the tinsel. This gives a good connection with the carbon while the other wire of the cord is attached to battery clip. Then attach the other two ends of the cord to the two remaining battery clips and attach to the battery.



This soldering "iron," built around a battery carbon, melts the soldering wire through which the heating current passes, when the wire is brought in contact with the carbon tip.

To use the soldering iron fasten the battery clips to the binding posts of the battery and the clip next to the handle to a strip of solder. Then when soldering press the point of the carbon on the solder, which will cause the solder to melt immediately.

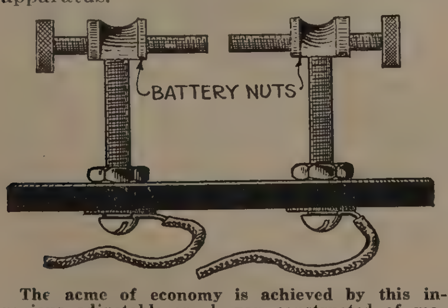
Another advantage of this soldering iron is that no current is used unless the carbon touches the solder, and that the iron heats immediately. There is practically no possibility of leaving current on over night.

Second Prize
Adjustable Spark Gap
By Roscoe Betts

THE simplest adjustable spark gap illustrated here, with the exception of the hard rubber base, is made entirely from old dry cell binding posts and nuts. Posts taken from Hot Shots are best, because they are of good length.

On top of two posts held upright by two flat nuts and jam screw are soldered two dry cell nuts which have been filed flat on one edge to provide a greater soldering surface.

Into the latter nuts are screwed two more battery posts which complete the apparatus.



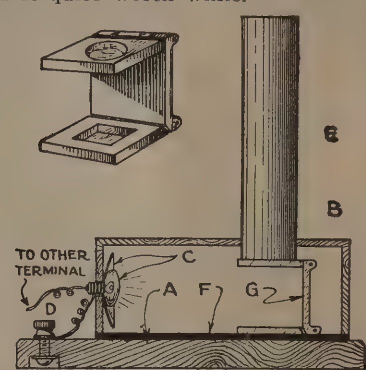
The acme of economy is achieved by this ingenious adjustable spark gap constructed of machine bolts and "dry-cell" binding screws and nuts. Besides economy and efficiency, it has the added virtue of neatness.

Third Prize
Electric Light Microscope
By A. Hymus

THE suggested microscope illustrated here is effective because of the illumination of the object. It is a home-made structure of fair power.

The parts are the following: (a) a wooden base; (b) a small wooden box with an opening or door on one side; (c) a flashlight bulb and reflector; (d) two binding posts; (e) a cardboard tube; (f) a small mirror the size of the box; (g) a small pocket microscope, obtainable at optician's for about 50 cents.

The apparatus is made up as shown in the illustration; first a base of suitable size is made and two holes are bored at one end for the binding posts. A small box is then made to fit as shown in Fig. 3. This has a circular hole cut in the top and another hole in the side, large enough to insert objects to be magnified. A hole made in one end receives a flashlight bulb. The tube can be made by wrapping stiff paper around a stick and gluing or shellacking. The microscope is easily made and is quite worth while.



The simple "linen-tester" is there put to novel use as a small microscope. The object viewed is illuminated by a small electric light.

First Honorable Mention
An Electric Churn
By Lester Schultz, Jr.

THIS is a churn interesting from its simplicity and small size. With it city people can have freshly churned butter and fresh buttermilk every morning for breakfast.

The materials required are these: A small electric motor; a storage battery or a toy transformer for house current. Even dry cells may answer in an emergency; a Mason fruit jar; a rod fitted with some kind of a paddle; two beveled gear wheels, one smaller than the other; and one coupling.

The paddle is attached to the rod, a hole giving a driving fit for the rod. The rod passes up through a hole drilled in the top of a quart Mason jar. The por-

(*Continued on page 132*)

$50 IN PRIZES

A special prize contest for Junior Electricians and Electrical Experimenters will be held each month. There will be three monthly prizes as follows:

First Prize	$25.00 in gold
Second Prize	$15.00 in gold
Third Prize	$10.00 in gold
Total	$50.00 in gold

This department desires particularly to publish new and original ideas on how to make things electrical, new electrical wrinkles and ideas that are of benefit to the user of electricity, be he a householder, business man, or in a factory.

There are dozens of valuable little stunts and ideas that we young men run across every month, and we mean to publish these for the benefit of all electrical experimenters.

This prize contest is open to everyone. All prizes will be paid upon publication. If two contestants submit the same idea, both will receive the same prize.

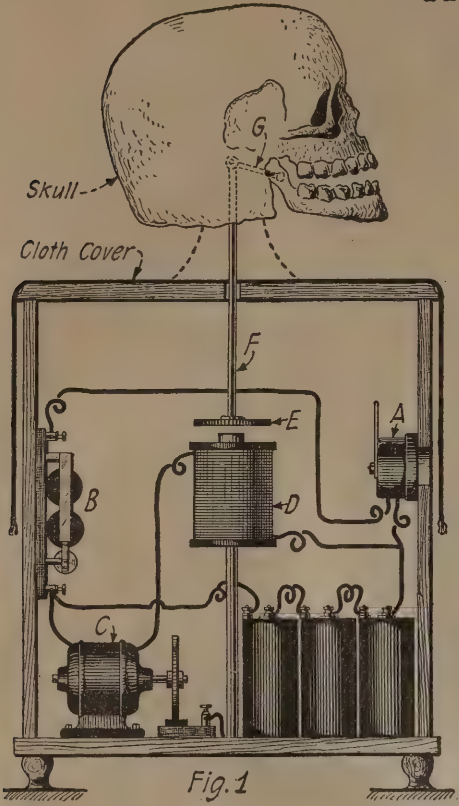
Address *Editor, Electrical Wrinkle Contest*, in care of this publication. Contest closes on the 15th of each month of issue.

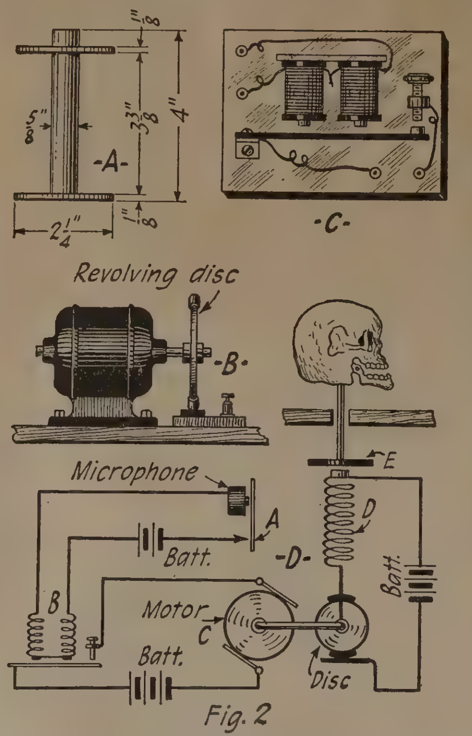
IN this department are published various tricks that can be performed by means of the electrical current. Such tricks may be used for entertaining, for window displays, or for any other purpose. This department will pay monthly a first prize of $3.00 for the best electrical trick, and the Editor invites manuscripts from contributors.

To win the first prize, the trick must necessarily be new and original. All other Elec-Tricks published are paid for at regular space rates.

An Electro-Magic Skull

By Homer Vanderbilt





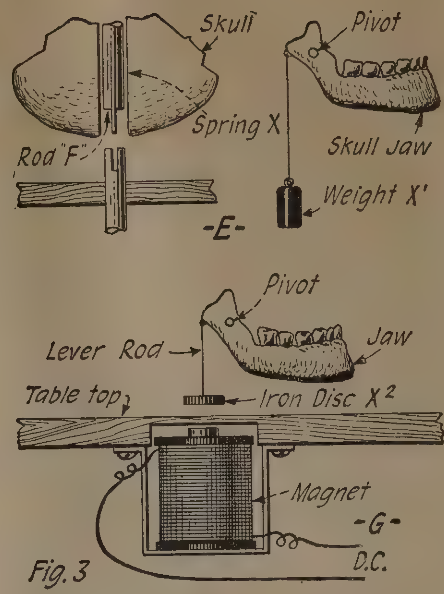


Fig. 1 shows the general layout of this rather startling experiment, the skull grimly opening and shutting its jaws and performing the other motions as described. Further details are given in Figs. 2 and 3, the whole thing constituting an interesting if somewhat ghastly display. The motor revolving a disc, operates the circuit breaker, affecting the magnet periodically. A relay is employed to give good actuating current.

MOST readers of this journal are undoubtedly familiar with the "rapping skull" used by stage magicians, but are possibly doubtful as to how it really works. Several of these schemes have been developed by different workers in the field, and one of these is herewith described in detail.

The general principles upon which this trick works are as follows: A sensitive microphone (A), Fig. 1, of the *carbon ball type*, is connected in circuit with a relay (B), see also Fig. 2 (D), and its armature circuit is linked with a motor (C) and battery. Upon the motor shaft a proper circuit breaker is placed and the latter is connected in series with a powerful electromagnet (D^1), actuating an iron armature (E), which is connected to a rod (F), operating lever (G), which is fastened to the (balanced) lower jaw of the skull, as perceived. Now, when you speak or produce any sounds near the instrument, the microphone will be disturbed, operating the relay, which will connect and work the motor, and in turn the circuit breaker. Consequently the electromagnet (D^1) is put in operation and the result is that the jaw is pulled up by the action of the rod (F) actuated by the magnet. When the current is released the slightly overbalanced weight of the jaw will cause it to drop back. The arrangement herewith shown will only cause a double rap of the jaw, but the number of them may be varied by increasing the number of segments on the circuit breaker.

The writer will unfold the details of his apparatus and thereby the experimenter will be enabled to build such a device for amusing his friends. It is certainly very amusing to witness the astonishment of the visitors when the skull is operated.

The constructional details of the individual apparatus are shown in Fig. 2. The electromagnet (A) is made to size, as perceived, and is fully wound with No. 22 B. & S. copper magnet wire. The circuit breaker (B) consists of a disc revolved by a motor and which makes contact with a brass strip located at the bottom of the base, as depicted. The relay (C) is made of two bell magnets actuating an iron armature carrying a contact point which coacts upon a second point, as seen. Connections for the various parts are shown in drawing (D). Practically any kind of relay can be advantageously used. The transmitter is of the supersensitive type and which can readily be made by following the instructions given in the November, 1915, issue of this journal on page 333 in an article entitled "How to Build a Dictaphone." After these various instruments are made they should be properly arranged as portrayed in Fig. 1 and connected as shown in (D), Fig. 2. The instrument is now finished and ready to be used. The only thing necessary to operate the jaw of the skull is to talk or blow a whistle, which will affect the transmitter and in turn the jaw, thereby causing it to rap startingly and mysteriously.

In conclusion several points may be mentioned which if followed will make the apparatus work and appear much more professional. Firstly, the contact disc had best be geared up to the motor, so that it makes about one revolution to 20 or more of the motor shaft. Again, the skull should be arranged so that it may be picked up from the stand and shown to the audience. At Fig. 3 (E), is indicated how a separable rod joint (X) may be contrived, enabling the operator to remove the skull easily for inspection. An indirect electrical method is the best way in which to actuate the jaw. At Fig. 3 (G), is perceived how the electromagnet (D) may influence magnetically an iron disc (X_2); joined to the movable jaw, as usual, by a lever or wire. This permits of minute inspection by the audience. Again, the effect can be attained by placing an aluminum ring in the jaw (properly balancing the jaw to make it work easily) and an alternating current electromagnet, by induction, will repel the ring (and hence the jaw also) whenever it is energized.

These latter schemes are merely suggestions that may be used to give the apparatus a professional appearance. A final word: it is absolutely necessary to mount the cabinet on a solid support, otherwise vibration will cause it to operate of its own accord and spoil the whole illusion by suggesting a mechanical cause.

Latest Electrical Patents

Keep Cool

Although the inventor of this device very ingeniously places an electric fan in the flashlight case, no provision is made for transporting fresh cells and disposing of the dead ones. Perhaps if a storage battery were used the motor could be run as a generator to keep it charged by blowing against the fan blades. A heater might be added for use in cold weather.

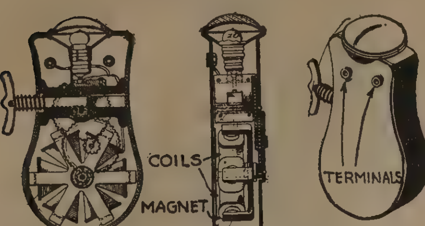
Patent 1,504,003, issued to A. F. Trumbull.

Phonograph

This phonograph is mounted in an ornament form, simulating an animal. By means of a switch a signal lamp indicates through the eyes of the animal when the record approaches the end of its journey, at which time the machine is automatically stopped. A lid in the back allows for exchanging records.

Patent 1,502,532, issued to Charles S. Tobin.

Flashlight



Current is generated for lighting this flashlight by pushing the handle in and out. A train of gears spins a magnet about the coils, causing the generation of current. Terminals are also provided so that the instrument may be used for testing outside lamps, bells, etc.

Patent 1,489,431, issued to Charles A. Drouillat.

Television

By analyzing an image into elementary portions and modulating a carrier wave in accordance with the space and intensity characteristics of each portion the image is transmitted by radio to the receiving station. A combination of photoelectric cells and electron streams makes the transmission possible. The illustration shows the receiving end of the apparatus.

Patent 1,470,696, issued to Alex. M. Nicholson.

Marine Disaster Signal

Means are provided for letting loose a signal buoy from a sunken submarine by the persons trapped therein. The buoy carries an electric lamp operated by storage batteries in the vessel, and also telephone equipment, so that the rescuers may communicate with the trapped party.

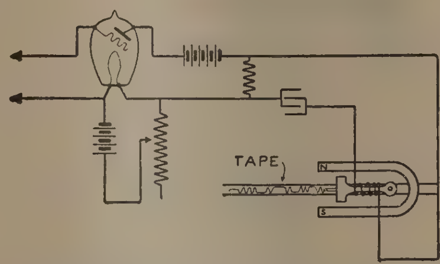
Patent 1,502,055, issued to A. P. Nastasiou.

Flashlight Stand

The object of this invention is to provide a suitable stand or support for mounting a flashlight so that it may be placed in any convenient location to facilitate the repairing of motor vehicles, etc.

Patent 1,481,998, issued to Harry H. Eldredge.

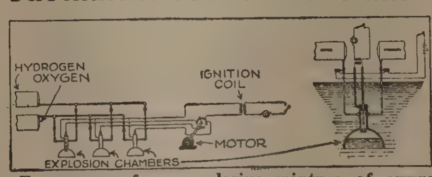
Wireless Recorder



A resistance is connected in the output circuit of the receiving apparatus, the variation in potential drop due to the received signals causing a current flow through the condenser and recorder. A stylus records the signals on a moving tape.

Patent 1,504,426, issued to W. M. Bruce, Jr.

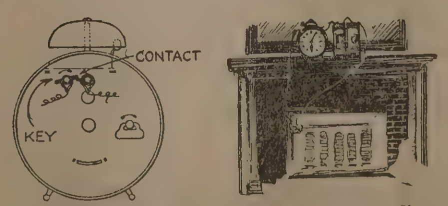
Submarine Sound Transmitter



By means of an explosive mixture of oxygen and hydrogen and an electric ignition system sound waves of a predetermined frequency are transmitted over great distances under water. The explosions take place in submerged chambers. An electric motor switches the ignition circuit to the various chambers at the desired frequency.

Patent 1,500,243, issued to John Hays Hammond, Jr.

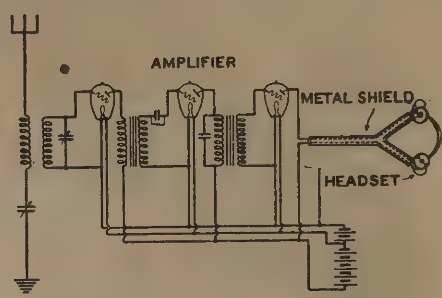
Time Switch



This switch is adapted for use on the ordinary alarm clock and is so arranged that the key makes contact and closes a circuit when it revolves, due to the winding off of the alarm, but does not make contact when winding up the alarm, in which case the contact point is turned to one side. It is used for operating buzzers, bells, lamps, etc.

Patent 1,500,512, issued to Carl W. Matson.

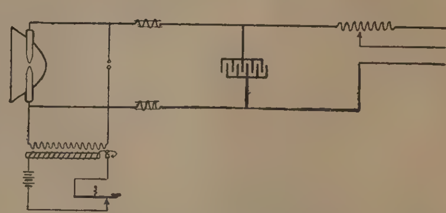
Shielded Telephone Cords



In many radio receivers the telephone cords cause difficulty in tuning due to electrostatic feed-back. This invention provides for shielding the cords with a suitable metallic shield connected to the filament circuit of the apparatus.

Patent 1,504,940, issued to G. W. Carpenter.

Signal Light



This signaling apparatus comprises an arc light connected to a D. C. line in series with suitable chokes and resistances. A condenser is connected across the line. Pressing the key energizes the spark coil, thus breaking down the resistance of the gap between the electrodes and allowing the condenser to discharge, giving an intensive flash. The flow of current stops after the condenser is discharged.

Patent 1,504,603, issued to L. W. Chubb.

Illuminated Target

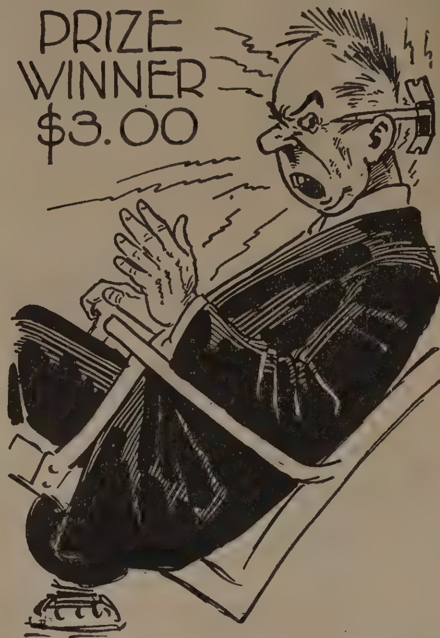
This target is for use on a leveler's rod. An electric flashlight is mounted on the rod, giving a luminous target upon which the leveler trains his instrument for reading the levels in the usual manner. Thus the device may be used in dark places.

Patent 1,500,482, issued to William J. Barrett.

SHORT CIRCUITS

THE idea of this department is to present to the layman the dangers of the electrical current in a manner that can be understood by everyone and that will be instructive, too. We have given monthly prizes of \$3.00 for the best idea on "short-circuits." Look at the illustrations and send us your own "Short-Circuit." It is understood that the idea must be possible or probable. If it shows something that occurs as a regular thing, such an idea will have a good chance to win the prize. It is not necessary to make an elaborate sketch, or to write the verses. We will attend to that. Now let's see what you can do!

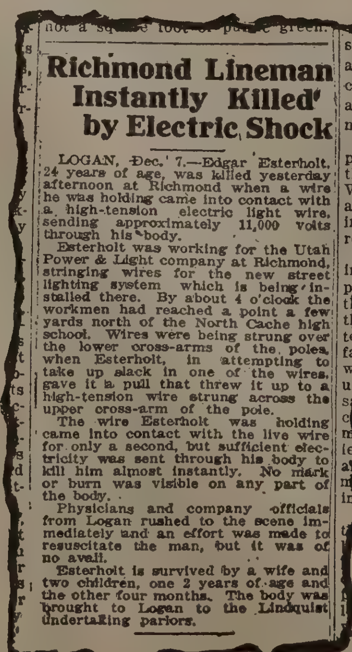
Beneath this earth
Is May Sentayenna.
For she hung the wash
On a "sending" antenna.
—PAUL SAFFRAN.



This spot is the grave
Of Peter LeDocket,
His silver pencil
Touched the wall socket.
—MARLIN LEFFLER.

Here in sweet peace
Lies Mrs. Beamer.
The register grounded
Her vacuum cleaner.
—MRS. A. HARTWIG.

Cold 'neath this sod
Is Jonathan Gwire.
His horse touched the tracks
And he touched the wire.
—PAUL SAFFRAN.



Richmond Lineman Instantly Killed by Electric Shock

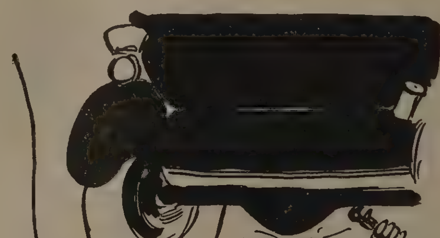
LOGAN, Dec. 7.—Edgar Esterholt, 24 years of age, was killed yesterday afternoon at Richmond when a wire he was holding came into contact with a high-tension electric light wire, sending approximately 11,000 volts through his body.

Esterholt was working for the Utah Power & Light company at Richmond, stringing wires for the new street lighting system which is being installed there. By about 4 o'clock the workmen had reached a point a few yards north of the North Cache high school. Wires were being strung over the lower cross-arms of the poles, when Esterholt, in attempting to take up slack in one of the wires, gave it a pull that threw it up to a high-tension wire strung across the upper cross-arm of the pole.

The wire Esterholt was holding came into contact with the live wire for only a second, but sufficient electricity was sent through his body to kill him almost instantly. No mark or burn was visible on any part of the body.

Physicians and company officials from Logan rushed to the scene immediately and an effort was made to resuscitate the man, but it was of no avail.

Esterholt is survived by a wife and two children, one 2 years of age and the other four months. The body was brought to Logan to the Lindquist undertaking parlors.



Lies under this stone
One Adolius Ramp
The damp on the floor
Grounded his lamp.
—P. C. HENRY.

THIS department is conducted for the benefit of everyone interested in electricity in all its phases. We are glad to answer questions for the benefit of all, but necessarily can only publish such matter as interests the majority of readers.

1. Not more than three questions can be answered for each correspondent.
2. Write on only one side of the paper; all matter should be typewritten, or else written in ink. No attention can be paid to penciled letters.
3. Sketches, diagrams, etc., must always be on separate sheets.
4. This department does not answer questions by mail free of charge. The editor will, however, be glad to answer special questions at the rate of 25 cents for each. On questions entailing research work, intricate calculations, patent research work, etc., a special charge will be made. Correspondents will be informed as to such charge.

Kindly oblige us by making your letter as short as possible.

Cracking Hydrocarbons

(482)—H. F. Fisher, New York City, asks:

Q. 1.—By what electrical process is carbon black obtained from gases?

A. 1.—All hydrocarbon gases are very rich in carbon content. Among these are acetylene, and the higher olefines. The molecules of these gases are more or less unstable and can readily be dissociated into their constituent atoms. Such dissociation may occur at very high temperatures. The electric spark is a very convenient method of producing the necessary heat for this purpose. The gas is passed through a spark gap over which a discharge of several thousand volts is passing. The molecules of the gas are set into such violent vibration that the constituent atoms separate and reunite to form molecules of the elements or of lower types of hydrocarbons.

This method of producing carbon black has not been developed into an industrial process as yet.

Substations

(483)—T. F. Long, Rochester, N. Y., asks:

Q. 1.—What is the function of substations on electrical railroads or lighting systems?

A. 1.—The location of power stations is largely determined by the location of the hydraulic power supply or by the convenience in transportation of coal or other fuel, so that very often the point of power generation is very far removed from the place of consumption. This condition requires that power be transmitted over great distances. Now it is known that electrical power is most economically transmitted at high voltage and low currents, but for use in electrical machinery such as railroad motors, heavy currents at comparatively low voltages are needed. Therefore, means must be provided for the transformation of the high potential into the low potential of the working system.

Further, power is often transmitted in the form of alternating current over high voltage transmission lines and is converted in the substation into direct current. Substations may, therefore, be of various types, ranging from those containing merely transformers, to the more elaborate forms, which house transformers and rotary converters or motor generators assume.

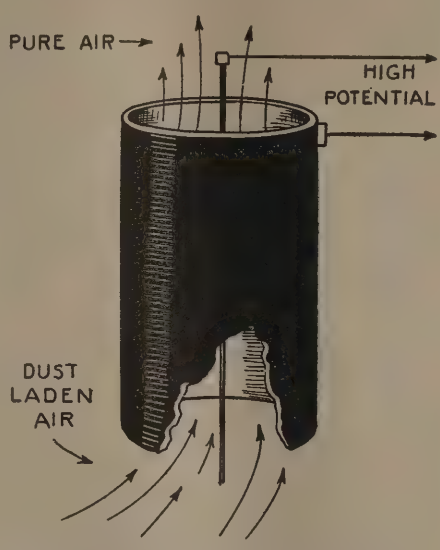
Electrostatic Separators

(484)—T. C. Oxon, Rio de Janeiro, Brazil, inquires:

Q. 1.—How can smoke or dust be removed from the air fed to an air pump?

A. 1.—Such separation of dust from air can be effected by the Cottrel precipitator. The essential features of this device are illustrated in the figure. It consists of a thin wire stretched along the axis of a metallic cylinder through which the air is passed. A high potential is applied between the wire and the surrounding cylinder and as a result a strong electrostatic field is set up between them. Since the wire has a very much smaller surface than the cylinder the electrostatic field will be stronger near the wire than at any other point in the cylinder. The dust particles suspended in the air passing through the cylinder will be charged by the wire and will then be powerfully repelled by it. Being driven by the electric force to the cylinder walls, they are attracted by the latter and retained there as the cleansed air passes on.

The speed with which these particles are removed from the air depends on the strength of the field, which for a cylinder of fixed radius is proportional to the



The Cottrel electrostatic precipitator, shown above, induces an electric charge in the solid particles carried by gases and then retains these particles on one of the electrodes. The process can be readily duplicated by the amateur experimenter.

applied voltage. Therefore, the faster the air is fed through the cylinder the larger must be the applied voltage to assure the complete removal of solid particles. Sometimes the solid dust products are utilized as sources of metals, etc.

Tesla and Oudin Coils

(485)—Norman Preisser, Albany, N. J., asks:

Q. 1.—Are Tesla coils, Oudin coils, spark coils and step-up transformers all operated on the same principle?

A. 1.—Essentially these apparatus all operate on the same principle, *i.e.*, transfer of energy from one circuit into another by electromagnetic induction. They differ only in design and application. The Tesla and Oudin coils and transformer are operated on alternating primary current, while spark coils operate on interrupted direct current, the interruption being accomplished either by mechanical vibrators or by electrolytic polarizing interrupters.

Soft-Tube Filaments

(486)—C. Williams, Atlanta, Ga., asks:

Q. 1.—Why do the filaments of soft tubes deteriorate more rapidly than those of hard tubes?

A. 1.—You will recall that the current through the vacuum tube is due to a flow of electrons emitted by the filament. These electrons bear a negative charge and are therefore attracted by the plate to which a positive potential is applied. In a high vacuum the electrons have a free path from the filament to the plate. But in a soft tube a large number of gas molecules are present in the space between the plate and filament, and the free electrons collide with these, knocking some electrons out of them. This process is repeated by the newly liberated electrons and a great increase in the number of free electrons results, thus increasing the plate current. While this is a favorable condition, it is accompanied by an effect detrimental to the filament. That is, since by the loss of electrons the gas atoms in the soft tube become positively charged they are attracted with great force by the filament which is negatively charged by the "B" battery. These positive ions are very massive and their incessant bombardment of the filament tends to destroy the surface of the latter.

It is on such close reasoning as this that the theories of electron relations are based, giving results at once picturesque and probable.

Weight of the Electron

(487)—T. F. Thomson, Chicago, Ill., asks:

Q. 1.—How is it possible to weigh an electron?

A. 1.—The mass of an electron is determined by an indirect process. By means of an apparatus similar to that described in the August issue of PRACTICAL ELECTRICS, in the article "The Cathode Ray Oscillograph," the ratio of the charge to the mass of the electron is determined. Then the charge carried by the electron is determined by condensing oil or water on it and observing the rate of fall of resulting charged drops of oil under the influence of gravitational and electrostatic fields.

Q. 2.—If the current is due to electrons emitted by the filament in a vacuum tube, why is the current influenced by the voltage between plate and filament?

A. 2.—The potential difference between filament and plate establishes an electrostatic field which exerts a force on the electrons. The motion of the electron thus becomes accelerated and this acceleration increases when the field increases, and therefore the current increases. However, the number of electrons emitted by the filament being limited, a plate voltage is soon reached which will cause the electrons to fall into the plate as rapidly as the filament emits them. This is a condition of saturation.

The Ark of the Covenant

By Victor MacClure

(*Continued from page 93*)

"Good boy," said he. "Now here's another point. During the day you'll be free to conduct your investigations, but I shall want you to fly me into the country every evening. I'm not going to stop in town and have the telephone buzzing in my ear all night. I'll keep Hazeldene open and live there. Can you do it?"

"Do it!" I cried. "Why, dad, there's nothing I'd like better—and if at any time I should be called away on this job, you'll find Milliken a first-class man."

"That's settled, then. I take it you have something better in your shed than the old seaplane you used this morning?"

"You bet. There's my own *Merlin.* Three hundred kilometres and more an hour are nothing to her. I'll have her tuned up for you right away. I can get you from the Battery to Hazeldene well inside the half-hour."

"Bully!" said the old man, and rose with a cigar going strong. "Now I must get back to the bank, son."

II

We drove back to the Metallurgical through streets that seethed with excited humanity. Newsboys were running about, offending the ear with unlawful and raucous yells, flourishing news bills that smote the eyeballs with their flaming scarelines. One journal, apparently despairing of adjectives sufficiently lurid to describe the reported enormity of the raid on the banks, had printed a sheet containing nothing but one large exclamation mark. Broadway was Babel. At every other corner policemen were trying to move on the crowds that inevitably clustered round each fortunate with a newspaper, and so dense was the press at the lower end of Broadway that it took two mounted men nearly a quarter of an hour to drive a path for the car through the last hundred paces to the bank door.

A Gold Coin from the East

Once we were inside, I immediately got through to my mechanic, Milliken, on the telephone, and told him to tune up the *Merlin.* Wise fellow that he is, he had anticipated the order, and could promise to have the plane ready in a couple of hours. Next I spoke to the housekeeper at Hazeldene and arranged for the place to be kept open for my father and myself. In the ordinary way I lived in a hut close to the hangar and workshops on the beach, only joining my father at Hazeldene when he went there for the weekends. He had been at the cottage on one of these visits when the news of the robbery had pulled him out of bed for our flight this Monday morning.

I was on the point of stepping out to make what investigations I could when my father called me into his room. He had come upon an old Eastern piece of gold money which he kept as a curiosity in one of the drawers of his desk. It was not of the ordinary disc shape, but was like two little beans stuck together crosswise and turned over each other. I had seen it before as a shining piece of particularly pure gold, but now it was sadly dulled to a color with which I was becoming familiar.

"You had better keep that, Jimmy," my father said: "I expect you'd like to have a sample of the tarnishing."

I was glad to have it, and I wrapped it in a scrap of tissue paper before placing it in an empty matchbox to keep it from being rubbed. I intended to have the tarnishing analyzed in the hope that the result would furnish some clue to the anesthetic used by the crooks, for to my mind the crux of the whole affair lay in the mystery of the two lost hours. This was the thing I determined to follow up in the best way I could. I had no other notion of where to make a start.

When I reached the street, the crowd in front of the bank was thinning before the maneuvers of the police, and I waited in the doorway until there was room to move. In a little while I was able to cross Broadway, and it was when I had reached the opposite sidewalk that a slight accident happened to me which was the means of furnishing another step in the development of my theories.

A Curious Powder in the Street

To avoid bumping into a fellow who was hurrying past on the sidewalk, I stepped short on the curb. My foot slipped and I came down on my hands. I felt my palms sting, as though I had landed on some sharp sand, but when I stood up to brush the stuff off, I saw that my skin was full of little splinters of glass. It was no conscious alertness that made me look down on the curb, but just the ordinary human foolishness that always makes a fellow turn to look when he has trodden on a banana skin. My interest was caught by a smear of powdered glass along the curb and in the gutter—like the result of breaking an electric bulb, only bigger. There was something about the pulverization and distribution of the stuff that made me look closer still. I was suddenly taken with a notion of what the stuff stood for, and I swept a few grains of the powder together and wrapped them in tissue paper, placing the tiny packet beside the coin in the match-box. My next idea was to have a look round the outside, at least, of the other banks.

I walked down Broadway to the Guaranty Trust and, acting on the idea that was simmering in my head, I scrutinized the sidewalks and the roadway round about. I half expected to come upon another of the smears I had discovered opposite the National Metallurgical, but was disappointed. There had been, however, a fairly dense crowd all down Broadway that morning, and I was not ready to dismiss the possibility that the same sort of smear had been in the street sure enough, until the trampling of many feet had dispersed it.

More of the Powder

By the Sub-Treasury, at the corner of Pine Street and Nassau Street, I had better luck. Here again the height of the curb had saved the smear of powdered glass from being completely obliterated. I took a sample of this, too, and numbered the package in which I folded it.

Next I went on down Pine Street until I came to the Dyers' National, but this time, although I worked as closely and as carefully as I could, I found no reward for my search. Remained then the last of the raided banks, the Trade Bank, and I walked round to take up my investigations there.

Right in the middle of Broad Street where it joins Wall Street, I found another sprinkle of powdered glass. Passing feet had made it very faint, but luckily the morning had been dry, and the traces left were unmistakable. I reckoned now that I had reasonable grounds on which to work out my notion, and I contented myself with picking up what I could of the powder on a finger-tip to test its nature. It had the same character as my two samples.

By this time I had four ideas firmly fixed in my head, and could not be quit of them: that the crooks had used an anesthetizing gas; that this gas probably had tarnished the gold; that the gas, in liquid form, had been held in glass containers; and that the smears of powder outside the three banks were what was left of the containers after the release of the gas had shattered them.

These were a weirdly fanciful lot of notions, I admit, but like the rest of those concerned, I was more absorbed by the idea of the mysterious sleep that had fallen on the district during those two dead hours than by the magnitude of the robbery itself. It was all guess-work, and probably mad guess-work at that, but at the time guess-work was about all anyone had to start from.

In any case, I thought the coincidence that smears of pulverized glass should be outside three of the robbed banks sufficiently strange to be worth working on, and in pursuit of the ideas it gave birth to I went in search of the policeman of the tarnished locket.

I was afraid he would have gone off duty, but my luck held, and I came upon him practically on the same spot where I had parted with him earlier in the morning. He had just been relieved and was going home. I walked with him up Broadway in the direction of the National Metallurgical.

A Slight Explosion and What Followed It

"There is a point on which I'd like to ask you a question or two, McGrath," I said.

"Shoot!"

"Before you fell asleep or became unconscious this morning, did you hear anything of an explosion?"

He stopped dead in his tracks to stare at me.

"Faith—now you mintion ut," he said slowly, "I believe I did hear a bit of a pop. Nothing to startle ye, mind—just a quiet little pop, like ye'd be hearin' when a child burst a paper bag."

"Where were you when you heard this pop, as you call it?"

"Let me see, now," he mused. "I'd be standin' right foreninst th' Exchange when I heard ut."

"You didn't hear more than one?'

"I might have. But, d'ye see, ut was the sort av noise that might be comin' from the uptown traffic, and not at all the noise that would swing ye round to see what ut was."

"How long after hearing the noise would it be before you became unconscious?"

"Now ye've got me, for ut's a thing I can't tell ye," the big fellow said. "I'm told that I was asleep for two hours—but, if ye ask me, I say ut was a bare five minutes from hearin' the pop until I woke up and found myself lyin' on the sidewalk."

"After the noise, did you become conscious of any peculiar odor—even of the slightest?"

"No, divil a whiff av any sort," he said positively—then with a twinkle, "unless maybe what was left behind from the big cigars av the millionaires."

"That might make your eyes water, but would hardly send you to sleep," said I. "Before you became unconscious, did you see any haze or mist coming up?"

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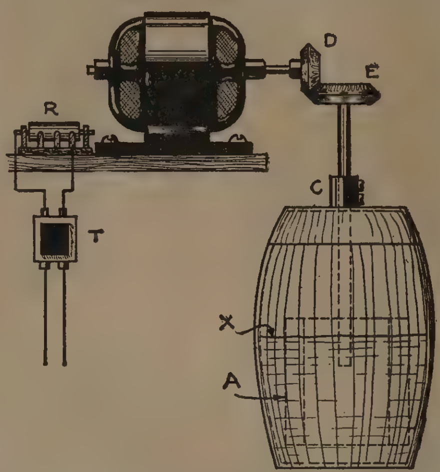
An Electric Churn

(*Continued from page 125*)



The electric motor drive in connection with the improvised churn, it may be from a Mason preserving jar, illustrated above, adapts the device to daily use in the city home.

celain must first be removed. The rod and paddle are assembled and the coupling is put on outside the cap of the jar so as to hold up the paddle and shaft. The large and small gears are put on and adjusted by trial.

When the power is turned on the paddle should turn around at a lively rate of speed. The churn should be supplied with "cream" until it is almost half full.

In 15 to 20 minutes of churning butter will begin to come. When you have churned enough, put half a teaspoonful of salt in the churn and start up the motor until the salt is well mixed in. Sometimes the butter has a whitish color; this does not affect the taste, and is a guarantee of purity.

The Ark of the Covenant

(*Continued from page 130*)

"There was nothin' but maybe a kinda blueness in the Street——" he began, then broke off: "B' the holy piper!" he exclaimed. "Come to think av ut, ut was an odd kinda haze, too!—like nothin' so much as the way the letters on me watch would show in a dark corner, or like wan av thim old-fashioned matches would be if ye was to spit on ut in the dark—but more spread about and thinned down."

"Ah, phosphorescent!"

"I wouldn't be puttin' a name like that to ut, so I wouldn't," he said carefully. "If ye understand me, ut was almost too faint to notice. All I say is the Street looked like ghosts might——"

"Thank you, McGrath," I told him. "You've given me just what I wanted to know."

"Is ut a bit av detectin' you're after?" he asked me. "Faith, Mr. Boon, ye've got things out av me that none av thim—polis or private—had the sinse to remind me av. One of me mates was sayin' that there's been some queer on-goin's up at the Post Office. Have ye heard anythin' at all about ut, Mr. Boon?"

I had forgotten Dick Schuyler's casual reference to the Post Office and my interest was reawakened.

"Commander Schuyler said something about it," I said to McGrath. "Was the Post Office gassed and robbed, too?"

"No. I wouldn't say that. I haven't got the rights av ut yet, but ut's just queer on-goin's that's rumored.

"Ut's a queer affair, so ut is," he went on, "and the more ye think av ut, the

queerer ut is. There's me locket, now. D'ye think I can get the polish back on the thing? Not wan bit av ut. Ut's all pitted an' dirty-lookin'. What the girl will say, Hivin knows."

"If you don't mind letting me have it," I volunteered, "I'll give you enough to buy another like it, and something for the girl as well. I'm interested in it."

"Have ut, and welcome," said McGrath. "I'd be thinkin' I'd better get a new wan, an' say nothin' to Norah about ut, for I wouldn't like her to see ut that dirty. I know the store where ut was bought. Let me get the photy av her out av ut, an' ut's yours."

He handed over the damaged trinket, and I gave him two ten-dollar bills. He was mightily pleased, for with the twenty dollars he could buy half a dozen lockets of the same kind, and when I turned into the bank he was grinning broadly as he went off to shoulder his way up the street. I added the locket to my tissue-wrapped trophies.

My next concern was to interview Jaxon and his five men again. Normally they would have left the bank by this hour, but they were still hanging round in some faint hope of cheering news. I collected the six of them in a spare room, and questioned them along the same lines as I had used with McGrath. They all reiterated their former statement that there had been no odor, but three of them, including Jaxon, recalled having heard a faint pop before dropping off to sleep, and their descriptions of the noise were, on the whole, fairly close to that given me by the policeman. Four of them, also including Jaxon, now positively remembered a faint luminosity, and the other two thought they did.

III

I now took my exhibits, as the police would call them, and my theory uptown to a friend of mine who has a great reputation in chemistry and physics, a clever little fellow called Dan Lamont, so well off that he can afford to have a first-class laboratory, and keep a big staff of assistants working on valuable but unremunerative research. He is a perfect little wizard, and many a time I had gone to him to be pulled out when the physics side of my work had me bogged.

Consulting the Chemist

"Hullo, Jimmy!" he said, as soon as he saw me. "What's the trouble this time? Won't the coefficients come unstuck from the dihedrals, or is it that the helicopter still refuses to copt?"

"You're wasted as a physicist, Dan," I told him. "You ought to go into vaudeville as the Un-funniest Back-chat Comedian Alive. Haven't you heard about the robbery?"

"I'll bite—and then you can say your smart answer," he grinned. "What robbery?"

There are days when Dan doesn't see a daily journal, and I guessed from his readiness to chaff that he had not heard about the banks. I told him. As I expected, he at once showed the liveliest interest.

"Well, Jimmy!" he exclaimed. "What do you know about that? Most interesting! Christopher Columbus and the hard-boiled egg! Are you telling me that Wall Street was put to sleep for two hours while a gang of crooks helped themselves?"

"That's just what I do tell you."

"Phew!" He stood up and stared at me. Then he took out his loose change and rattled it in his cupped hands—a trick he has when very excited.

"What makes you think the crooks used gas?" he demanded.

"I can think of no other way in which

they could dope the district," I said. "Can you?"

The Gas Theory

"They might have fixed the water supply," he said softly. "No. Water isn't popular enough with the police and the watchmen to make that method effective. But, gas——!"

"What's your kick at the gas theory, Dan?"

"Haven't you said that the people who went to sleep smelled no odor?"

"That's right. Not a thing."

"Then there isn't any gaseous anesthetic known could do it," said Dan. "Let's see. The absence of odor rules out chloroform and ether straight off. Ethyl chloride—no—too smelly—and too lethal. You say nobody's dead?"

"Not a soul so far."

"Queer, queer! Nitrous oxide has no smell, but its effects last barely a minute. There may be a gas could do it, Jimmy, but I've never heard of it. What makes you so keen on the gas idea, anyhow?"

I told him about the powdered glass, and showed it to him. Then I brought out the locket and my father's gold coin. Dan's excitement grew.

"This is mighty interesting, Jimmy—mighty interesting," he purred. "I never heard of anything to tarnish gold in this way. Chlorine?—chlor—— Hey?" he broke off as he examined McGrath's locket. "Who told you this was gold?"

"It is gold," I insisted.

"Looks more like copper to me."

"Oh, shucks, Dan! It probably has a large percentage of copper in the alloy."

I brought forward the instance of Jaxon's watch, but he took little notice of what I said. He was off on some scientific day-dream.

"This coin, too," he brooded. "At first sight I'd say it was copper."

"That's where you fall down, young fellow." I said. "That coin was kept by my father as being a remarkably pure piece of gold. He had it tested."

"May be so, my dear Jimmy—may be so," he said absently. "I'll tell you what. I'll analyze this tarnishing. Leave the locket and coin with me. They look to me to be impure alloys of copper—both of them. Most interesting! I can think of nothing to affect gold so."

"No more can I, Dan," I said, "but I can think of none more likely to find out than yourself. When can I come back?"

"Eh? Oh—ah—yes! Come back, eh? Oh, sometime this afternoon," he muttered, his gaze fixed on the coin and locket. "Gas, eh? Must think about it. Good fellow, Jimmy—to give me these. A new thing—mighty interesting. Goodbye, old man——"

He wrung my hand and made a bee-line for his laboratory, with the coin and locket held out in front of him in his cupped palms. I chuckled to think I had made Dan Lamont so interested, for I knew that the chemistry side of any investigations I wanted to make was in the most skillful hands in New York. I had enlisted the services of a powerful ally.

IV

In the Post Office

The next thing I had to do was to get the *Sieve* back to Long Island and see how Milliken was getting on with the *Merlin*, but on the way down to the jetty I stopped to look in at the Post Office. There was a jam about the place, and the counters were crowded up. I wrote the name of the bank on one of my cards under my own name and handed the pasteboard to a messenger.

"Are you Mr. Boon?" he asked suspiciously.

"I am," said I.

"Who is it you want to see?" he demanded.

"Anybody in authority who has a minute to spare——"

"Will Mr. Glover do?"

"Fine," I said. "Lead the way to Mr. Glover."

He conducted me along a passage into a nest of private rooms, and tapped at a door.

"Wait here," he said, and went into the room. He was out in a second.

"Mr. Glover will see you."

A bald-headed man at a desk in the center of the room looked up with an ingratiating smile as I came in, but when he saw me his grin froze, and he rose in angry surprise from his chair.

"What trick is this?" he demanded. "You are not Mr. Boon, sir! You are an impostor, sir—an impostor! Let me inform you that I am familiar with the appearance of the president of the National Metallurgical! I am an acquaintance of Mr. Boon!"

"That's fine," said I. "Allow me to introduce to you his son, James Vandersluyt Boon, whose card you have in your hand."

He looked at me suspiciously for a moment, then smoothed down, and held out his hand. I wondered at the change in his reception of me, but next moment it was explained.

"Of course, of course!" he said heartily. "I might have known!" He waved a hand at the flying-kit I still was wearing. "You are the young conqueror of the air, our modern Icarus—though I trust not doomed to the same fate. I trust not," said the pompous ass. "Well, Mr. Boon, and what can I do for you?"

I told him pretty snappily that I wanted a line on what had happened in the Post Office that morning, explaining that I was investigating everything that seemed to have any connection with the robbery of the banks.

Mr. Glover looked hurriedly round the room, as if he were afraid somebody might be lurking in a corner. He dropped his voice mysteriously.

"This is, of course, strictly *entre nous*," he said. "I can say nothing officially, you understand? It must go no further?"

I said I quite understood—and found myself whispering like a fool when I said it.

The Five Packages

"Very well, then," said he. "I will tell you, Mr. Boon. A very strange thing happened here this morning. Five little packages, extremely heavy for their size, were dropped into the local collection box during the night or in the early hours. The box was cleared at seven, Mr. Boon, and it was then that they were found. They would have escaped notice, I do not doubt, had it not been for the peculiar circumstances that they were all without the requisite stamps—unstamped, Mr. Boon! The sorter put them aside, and when he came to deal with them later, he found that there were also five bulky envelopes, similarly without stamps. Now, here is a curious fact, Mr. Boon"—with another apprehensive glance about the room—"both the envelopes and the packages were all addressed to important hospitals and research institutions in the city, an envelope and a package to each of five institutions!"

He leaned back to see the effect on me of this thrilling revelation.

"You amaze me, Mr. Glover," said I. "Certainly a peculiar and suspicious circumstance."

"Wasn't it!" Mr. Glover agreed. "The packages were all alike, and appeared to consist of heavy little boxes wrapped in corrugated cardboard and brown paper. Well, now. Naturally the Office was agog with the news of the dastardly outrages in Wall Street, and the sorter somehow connected these envelopes and the pack-

ages with the crime, Mr. Boon. He summoned his immediate chief, and the result of their colloquy was that packages and envelopes were held over for investigation by our police department."

(To be continued in our next issue)

Nobili's Rings
(Continued from page 115)

In passing the current through the lead solution the lead is deposited on the surface of the metallic plate in the usual manner. Oxygen, however, is also liberated at the same time and this oxidizes the metallic lead to lead peroxide as soon as it is deposited.

The reason for the beautiful display of colors exhibited by these lead peroxide films lies in their extreme thinness, which causes interference of the light waves striking their surface and being reflected through them by the metal surface behind.

Quick-Action Alarm Switch
(Continued from page 80)

bend. Then when the alarm key turns it will drop the little weight, which will close the switch with a jerk. A strong cord can be used in place of the chain.

The good points about this switch are these: It is quick and sure in action; it is easy to make and looks neat; also it requires no alterations in the alarm clock and the clock does not have to be fastened down. Thus the clock can be used elsewhere when not employed for the switch. If the clock ever needs repairs another one can easily be used in its place. So the switch will always be in working order when wanted.

Pneumatic Miner's Lamp
(Continued from page 82)

maintained within the case. Thus gases or explosive mixtures cannot get in, so that even if there were sparks produced within the case, nothing would happen.

A small hole leads from the case to the outer atmosphere so that a steady stream of air is constantly passing out; this operates to maintain pure atmosphere within the case. If the said pressure does fall, it automatically cuts off the current and the lamp goes out. The air nozzle admitting air to the turbine is provided with a strainer to restrain dust and keep the nozzle clear.

Different sized nozzles are supplied to give operation at from 35 to 120 pounds per square inch. A 25-watt bulb is used and to drive the turbine from four to five cubic feet of air per minute are required. The lamp in its mounting weighs in the neighborhood of 15 pounds; although it is rated from 24 to 36 watts, 12 volt automobile head lamp bulbs are used. The lamp may have a reflector or opal glass as desired.

Single-Tube Reflex Experiments with Hook-Up Board
(Continued from page 87)

plate-circuit of this tube. This circuit, having a loop aerial, two crystal detectors, and one tube, gives loud-speaker volume on local stations.

Single Tube Tropadyne Receiver

By combining the oscillator and the detector of a super-heterodyne much better results are obtained, as with this circuit only one crystal detector is required.

Fig. 12 shows the circuit embodying the tropadyne principle. The coil P-B-F-G is the same as the one used in the other super-heterodyne circuits except that it has a center tap as shown. The coils (L) are each of the 600 turn honeycomb type shunted by fixed or variable condensers. The resistance (R) should be one-quarter megohm. A loud-speaker was successfully operated when receiving local stations on this circuit. With a headset extreme distances were covered.

Reflexed Tropadyne Receiver

By reflexing the circuit, Fig. 12, we can obtain much greater volume and distance. The reflexed circuit is shown in Fig. 13. With possibly the exception of the super-regenerative receiver this is the only circuit that successfully operates a loud-speaker on a single tube, when using a loop aerial. This circuit needs little explanation. It is the same as the one shown in Fig. 12, with the addition of an audio transformer which feeds the output of the crystal detector circuit into the grid and filament of the vacuum tube, where it is amplified and is next reproduced in the loud-speaker.

In our next issue we shall show a number of two tube reflex circuits. Only the best of circuits will be shown embodying the latest improvements of the 13 hook-ups which we have just described.

Experimental Short-Wave Receivers

(*Continued from page 101*)

is urged that the greatest pains be taken in the adjusting of the oscillators for this class of work for the over-all results to be obtained by care are well worth while.

In conclusion, let me mention another type of set or rather inductance that seems especially suited to work below 50 meters. These inductances consist of the required number of turns of No. 16 enameled wire wound on a form one inch in diameter and then released therefrom, making a sort of large coil spring. The size of the wire will be sufficient to make the inductances self-supporting for use on all waves below 50 meters. The set may be wired up in the regular manner and six small binding posts arranged across the top of the panel to which the six terminals of the inductances can be fastened. In fastening the inductances to the binding posts they should be stretched slightly to partly separate the different turns, especially the secondary coil.

Coils of various number of turns are wound and connected to the binding posts as needed for covering different ranges of wave length. The largest coil should not have over 60 turns for the secondary and about 40 or 45 turns for the plate. About 20 turns will be correct on the average for the primary. Such an arrangement will tune to well over 50 meters and plenty of room in the number of turns is then left to go on down to extremely short waves. The advantages of such an arrangement for the real short waves is minimum of parts, excellent separation of the opposing leads of each coil, nothing but air dielectric inside of the coil windings and a good separation of the coil windings (depending upon the spring given to them in connecting to the binding posts). Experiments with hexagonal or square forms of winding do not seem to lead to any advantageous results. Many experiments may be made with such a set, and actual tuning over a considerable range of frequencies may be accomplished by simply varying the distance apart between the various turns, the coils act as a spring.

Engineers Association Opens Way To Big-Pay Electrical Jobs For 500 Young Men

Shortage of available trained men for big-pay electrical jobs has prompted the Associated Electrical Engineers to undertake, at their headquarters in Chicago, a unique training enterprise designed to supply the needed man-power. A new method, originated by their engineers, is reported to combine actual electrical practice and training in a way that enables any young man, with or without education, to become a trained Electrical Expert within 12 months, with earning capacity of $10 to $15 a day. By confining the training entirely to practical electrical work, they have cut down the time required to only one hour per day. A complete outfit of practical equipment is supplied, so that the necessary experience may be gained in training. 500 young men are to be admitted, and a number of places are still open. Any young man of good standing, with a desire to better himself, is invited to write, at once, to the Associated Electrical Engineers, Dept. 41, at 537 South Dearborn St., Chicago, Ill.

The Dance of the Carbon Atom

(*Continued from page 103*)

readily be obtained from wood alcohol. Fill a small glass or beaker one-eighth of an inch full of wood alcohol. Make a small spiral of platinum wire. Heat the wire red hot and suspend it just above the alcohol. The wire will continue to glow as formaldehyde is given off.

Take the oxygen atom itself, if its two free ends are united with a hydrogen each, then water is formed.

The dance becomes still merrier when two oxygen atoms are united to a carbon, then an entirely different substance results, namely, carbon dioxide, the gas exhaled by man and beast and utilized by the plant in its formation of sugar and starch as well as fats.

To return to marsh gas. If one of the hydrogen atoms is taken away and a nitrogen atom placed in its stead, nitrogen having three free bonds, and these are linked to one of carbon, and the two free ends to two hydrogen, then methylamine is formed, a compound somewhat like ammonia and forming salts like it.

The nitrogen atom, as we have seen, has three bonds, and if these three bonds are united to three bonds of one carbon and the remaining bond of the carbon links a hydrogen, then one of the most deadly poisons is obtained. This is hydrocyanic acid, also known as prussic acid.

The dance of the carbon atom continues; its four hands are capable of uniting with four atoms having but one hand, two atoms having two hands, and one atom having three hands, but not content with this, carbon is able to link hands with other carbon atoms, and this increases the complexity or organic chemistry, for organic chemistry is the study of the carbon dance, a study of the linking of bonds with each other and with other substances, and of a great many compounds the number of carbons entering into their make-up is still an unsolved mystery.

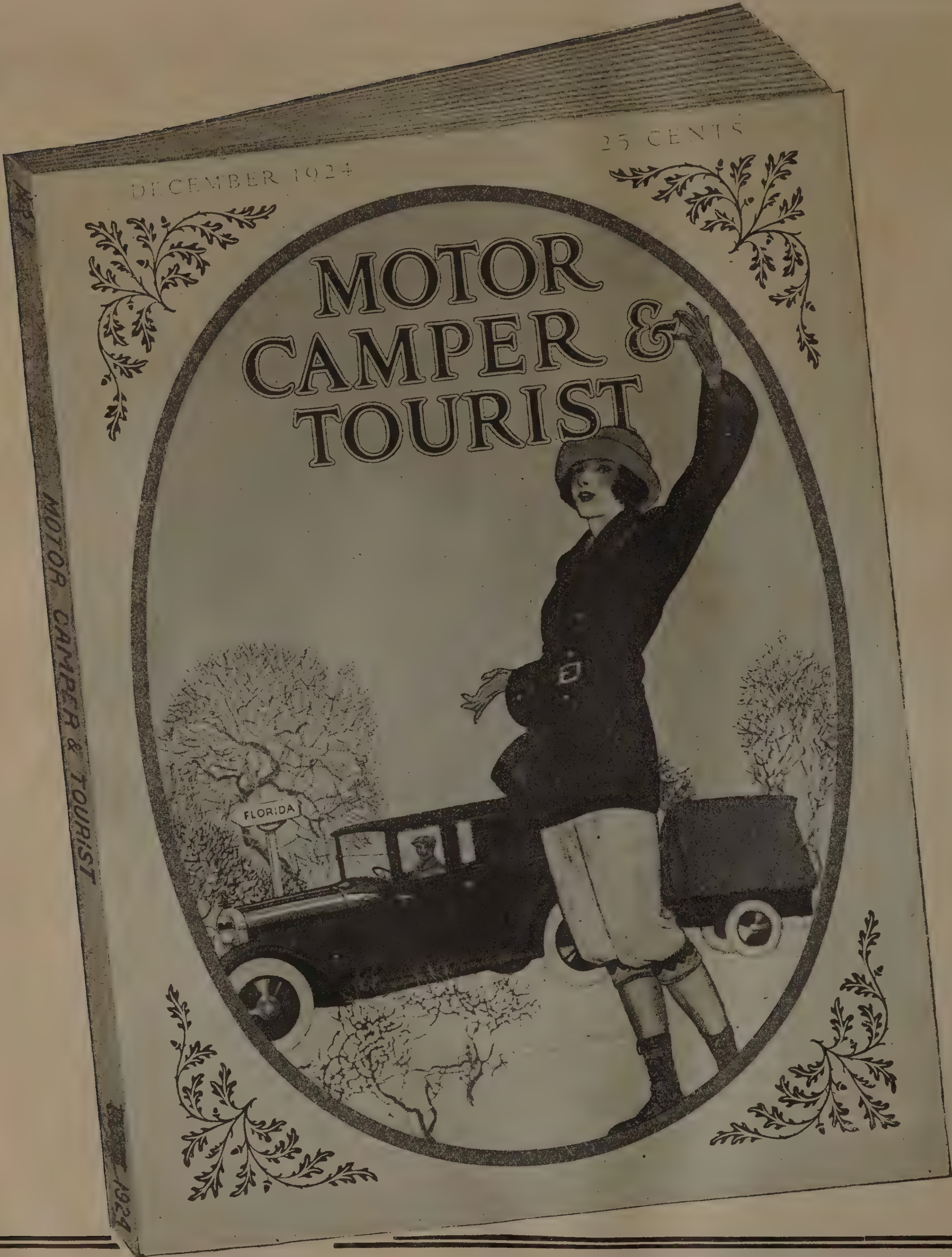
Building a Power Vacuum Tube

(*Continued from page 113*)

the sodium. When this is heated it takes up all the oxygen, nitrogen, and other gases in the tube, leaving mostly argon. When this is done we have about 1 per cent of an atmosphere pressure of practically pure argon in the tube. This makes a genuine tungar rectifier, the name signifying a tungsten filament in an atmosphere of argon. This makes a tube not quite so soft as the former one, but easier to handle.

Finally, the ambitious experimenter can make a moderately hard tube by this method, using sufficient care, and keeping the tube always connected to a vacuum pump. By following the directions for an electric vacuum pump to be given in a later article this should be readily possible. The tube can be built in much the same way, except that certain refinements will suggest themselves to each experimenter.

No data has been obtained on the ability of the three electrode tubes described above to oscillate, but they could undoubtedly be made to do so. One further modification is to be described, which is of great interest since it prolongs the life of the filament indefinitely.



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Of PRACTICAL ELECTRICS, published monthly at New York, N. Y., for October 1, 1924.
STATE OF NEW YORK—
COUNTY OF NEW YORK, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Hugo Gernsback, who, having been duly sworn according to law, deposes and says that he is the Editor of the PRACTICAL ELECTRICS and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
Publisher, Experimenter Publishing Co., Inc., 53 Park Place, New York City.
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